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LETHAL MIDLINE GRANULOMA, IS IT A PATHOLOGICAL ENTITY?*

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The dramatic clinical picture of progressive ulceration and tissue destruction of the nose and palate, until the whole face may have been eaten away, has been of great interest and study since it was first described by McBride in 1896 The seemingly relentless course of the destruction, in spite of all therapeutic attempts, leaves a profoundly unpleasant and helpless impression found in few other conditions

At first considered rare, more cases have been reported as the condition has become recognized with greater frequency Subsequent observers have added to the variety of nomenclature as well *It would seem that arriving at an absolutely uniform name would not be as important as establishing exact criteria which will define the disease*

This study was stimulated by observation of our own cases of lethal midline granuloma and those of colleagues and institutions in our area In addition, we reviewed the case histories under this heading at the Los Angeles County Hospital since the inception of this institution's disease classification system We believe that too often a fatalistic attitude has been adopted because of the discouraging prognosis presented by this disease in the past This has been responsible for paralysis of action, and has served to overlook other con-

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[illegible] be masking as lethal midline granuloma, and where available specific therapy could be life saving

From the evidence available which will be presented, it is doubtful whether lethal midline granuloma has the pathological characteristics of a pathognomonic disease The question, then, may be logically posed whether it should continue to be regarded as a pathological entity It is our purpose to review the salient features of this condition and to appraise critically the pathogenesis and pathological diagnosis in the light of current concepts in the literature and of our personal experience

Historically, the first case of progressive ulceration of the nose which ended fatally was recorded by Peter McBride[1] in 1896 in the *Proceedings of the Laryngological Society of London*, under the title, "Case of Rapid Destruction of the Nose and Face" No further reports appeared in the literature until 1921 when Woods reported two cases under the name of "malignant granuloma of the nose" A small number of other cases followed in the English literature, notably by McArthur under the same title, and in the French literature in 1929 under the name of "sacro-lupus pernio," by Chatelier[4] In 1933 there appeared a comprehensive paper on the subject by Stewart,[5] to which reference is made by most of the succeeding authors in the field He called it "progressive lethal granulomatous ulceration of the nose" Williams,[6] in his excellent study of present views on the subject, termed it "lethal granulomatous ulceration of the midline facial tissues"

Other terms applied to this entity include "granulomatous ulcer of the nose and face" (Hoover[7]), "chronic granulomatous ulcer of the nose of unknown cause" (Isbell[8]), "chronic infectious granuloma of the nose" (Lierle[10]), "osteomyelitis necroticans" (Rasmussen[12]), "gangrenous osteomyelitis of the paranasal sinuses (Lewy[11]), and "mutilating granuloma" by Wood[13] which, incidentally, was the first American case reported

Terms such as osteomyelitis or malignant reticulosis, mesenchymoma and others, which refer to specific inflammatory or neoplastic conditions should, it would seem better be left out, since this disease does not come under any presently known clinical entity or etiology. For the purpose of this study we shall refer to this condition as "Lethal Midline Granuloma."

The most vivid and edifying clinical description of the course of this disease is that given by Stewart.[2] He divided the symptomatology and pathological progression of the disease into three stages. He called the first, the prodromal stage, the second, the stage of active disease, and the third, the terminal stage.

The prodromal stage is characterized by intermittent nasal obstruction often accompanied by watery or serosanguinous rhinorrhea. Occasionally, however, the disease may be initiated by the appearance of a superficial ulceration in the nasal vestibule, nasal septum, or soft palate. In some patients, a history of pre-existing infection of the paranasal sinuses can be obtained. Surgical procedures in the nose usually conclude unfortunately. A perforation of the septum and delayed healing may be anticipated following a submucous resection. This stage may exist from several weeks to several years.

In the second "period of active disease," the persistent nasal obstruction becomes aggravated and is accompanied by a more profuse and maladorous purulent or serosanguinous discharge. It is usually of from 10 to 18 months' duration and is the stage when active therapy is imperative before excessive destruction of tissue takes place. The characteristic feature of this stage is the appearance of a gray necrotic patch on the nasal septum, turbinate, floor of the nose or palate. This breaks down rapidly and a shallow ulcer appears. The ulceration spreads progressively from the roof of the mouth or palate to the nasopharynx and nose, and from the inside of the nose erodes outside to the face.

Early in the involvement of the facial tissues, the nose and paranasal structures become indurated and swollen. As the lesion progresses, the palatal, nasal and malar bones, together with the contiguous soft tissues, undergo necrosis and sequestration. Abscesses may develop in the soft tissues, but there is no evidence of severe sepsis. The temperature is irregular, being normal or slightly elveated, and the leukocyte count may be normal, slightly elevated, or even show a leukopenia.

Agranulocytosis has never been found, and septicemia, as indicated by blood culture, is uniformly absent. The most striking observation of this second phase is that despite the apparent gravity of the destructive lesion, the patient presents an impression of well-being except for varying degress of weakness and lassitude.

In the third, or terminal stage, the prominent features are the obvious exhaustion of the patient and the extreme mutilation of the advancing lesions. The eyelids are swollen and a purulent discharge exudes from between the lids. Numerous areas of swelling and sloughing appear over the lacrimal sac, cheeks and external nose. The destruction may be extreme in some cases, with the loss of the central portion of the face and development of a large central aperture through which the roof of the nose and nasopharynx may be visible. The nasal septum, turbinates and lateral walls of the nose may have been obliterated, leaving the lateral walls of the maxillary sinuses and malar bones exposed. The pharynx and larynx may be extensively necrosed. The margins of the gaping lesion are indurated with rolled, heaped-up tissue covered with a dirty brown or greenish-brown heavy crust, and exuding a fetid odor of putrefaction. Strangely, the tongue remains unaffected and no destruction of the basi-sphenoid has been reported. Generally, there are little or no complaints of pain. At this stage, recurrent hemorrhages, due to erosion through blood vessels, may cause sudden death. Usually, however, the fatality results from exhaustion and manition with accompanying high terminal temperatures.

DIFFERENTIAL DIAGNOSIS

Clinically, there is nothing in the gross appearance of these lesions which would differentiate them from specific infectious granulomatous ulcerations or neoplasms in the same locations. The responsibility of the clinician is particularly important in the matter of a careful differential diagnosis and calls for every laboratory aid he can muster.

In observing a number of these cases, it is apparent that the pathologist, as well as the clinician, must be alerted and kept informed of the progression of the lesion In at least one of our cases, the mere pronouncement of the diagnosis of "lethal midline granuloma" had a tendency to paralyze initiative in searching for active and effective help It was only through repeated and diligent examination by a number of pathologists that we were able to classify the condition more specifically as of neoplastic character, and thereby institute vigorous countermeasures The patient is alive today and has been a source of stimulating investigation in this problem (see Case 1)

Diagnosis of lethal midline granuloma is made by history, clinical findings and, most important, by exclusion of other diseases causing similar lesions Conditions to be considered and excluded in a differential diagnosis can be listed as follows

1 Syphilis, *2* Tuberculosis, *3* Neoplasm, *4* Fungous infections, *5* Bacterial or protozoal infections, *6* Anemia or blood dyscrasias, *7* Diabetic gangrene, *8* Erythema multiforme, *9* Pemphigus, *10* Wegener's disease, *11* Leprosy, *12* Glanders, *13* Anthrax, *14* Tularemia, *15* Yaws, *16* Leishmaniasis, *17* Mycosis fungoides, *18* Noma, *19* Boeck's sarcoid, *20* Rhinoscleroma

Ulceration of the nose instantly suggests syphilis, tuberculosis and neoplasm It is well to remember that neoplasm may coexist with both tuberculosis and syphilis X-ray and laboratory studies should include cultures for tubercle bacilli, and negative findings should be confirmed by animal inoculation Biopsies should be adequate in size and be repeated without hesitation if the diagnosis is in doubt

Other conditions causing tissue changes characterized by granulomata and local tissue destruction would include fungous infections (particularly actinomycosis, coccidiomycosis and histoplasmosis), Boeck's sarcoid, leprosy, glanders, chronic tularemia, anthrax, rhinoscleroma and yaws

Biopsies and cultures for the fungi, aerobic and anerobic bacteria, and serological tests for typhoid, tularemia and undulant fever should be done Biopsies from early lesions are most revealing in histoplasmosis and scleroma [1]

Forbus[11] stated that etiologic diagnosis of inflammatory granulomatous disease presents very great difficulty in spite of the fact that specific sensitization of the skin is a characteristic feature of some of the granulomatous infectious diseases Prominent among this group are tuberculosis, brucellosis, tularemia, typhoid fever, coccidioidomycosis, venereal lymphogranuloma and histoplasmosis The production of so-called sensitizing antibody may be a feature of granulomatous inflammation, yet a typical granuloma may occur without demonstrable antibodies It is of interest that other forms of immune bodies may also be present in these infections and are of value in the laboratory tests for differentiation Complement-fixing antibodies appear in significant quantities in syphilis, coccidioidomycosis and some of the parasitic granulomatous infections Opsonins, agglutinins, and precipitins appear in brucellosis and typhoid fever Myiasis and Leishmaniasis, although rare, are the two important parasitic diseases to be considered Myiasis can be readily ruled out by careful inspection Naso-oral Leishmaniasis may be difficult to exclude completely because, in the late stages, the Leishmania may be scant or absent [1] It has been reported that in some tropical areas this parasite can produce early destruction of the nasal septum and necrosis of the alae nasi just as it occurs in syphilis, yaws, leprosy and lethal midline granuloma

In anemia, agranulocytosis or leukemia, ulcerations about the nose and face can be differentiated from those due to lethal midline granuloma by the blood pictures and natural histories of the diseases The blood picture in lethal midline granuloma will show the white cells in an approximate normal proportion with no morphological changes

Pemphigus may manifest itself first in the nose and pharyngeal mucosa in the form of vesicles, necrotic areas and ulcerations The Macht-Pell phytotoxin test will be of diagnostic aid in suspected cases [1]

Diabetic gangrene usually attacks the extremities, but may involve the face There should be little or no difficulty in determining the disturbed sugar metabolism and its associated vascular changes causing the gangrene

Gangosa (rhinopharyngitis mutilans) is found in subtropical countries and mostly affects natives The disease starts as a superficial ulcer on the posterior pharynx or palate characterized by a dirty brown scab Destruction of the nose and palate may take place[16] Except for the prognosis, which is rarely fatal, and geographic area from which the patient comes, there is little to differentiate this lesion from the lethal midline granuloma type[17]

In erythema multiforme, the common papular lesion is characteristic when it forms the "iris" lesion by peripheral extension and central clearing The histologic appearance is of value[18]

Another nonspecific granulomatous nasal lesion associated with polyarteritis nodosa, or other collagen disease changes in the arterial system and kidneys, was described by Wegener[19] in 1939 Since then, a number of accounts have appeared in the literature describing granulomata which, while not so locally destructive as the lethal midline type, nevertheless proceed to a fatal issue Death is usually due to anemia, and postmortem examination reveals changes in the spleen, kidney and other organs suggestive of polyarteritis nodosa

PATHOGENESIS RELATING TO ALLERGIC TISSUE REACTION

An important concept in the development of granuloma is the role that the allergic state or local tissue immunity plays in its production Consideration of the implications of anephylactic inflammation may cast a new light on the basic pathological changes and, therefore, ultimately the treatment of lethal midline granuloma Most of the recent work in the fundamental nature of granuloma formation and tissue destruction has followed in the path of immunological or stress effects on tissue changes

An interesting chain of evidence can be collected from the literature relating the pathogenesis of lethal midline granudulant fever should be done. Biopsies from early lesions are most revealing in histoplasmosis and scleroma.[1]

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In anemia, agranulocytosis or leukemia, ulcerations about the nose and face can be differentiated from those due to lethal midline granuloma by the blood pictures and natural histories of the diseases. The blood picture in lethal midline granuloma will show the white cells in an approximate normal proportion with no morphological changes.

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Diabetic gangrene usually attacks the extremities, but may relationship of tissue changes in immunological reactions, and how it connects with the problem of idiopathic granulomatous ulceration under discussion.

The concept of tissue immunity has been extended and developed by Kahn,[24] who has, in particular, called attention to the defensive properties of the skin and subcutaneous tissue. When an antigenic agent is injected into the skin of an immunized individual, it is anchored locally and is circumscribed by an inflammatory reaction. Kahn[25] found that anchoring of micro-organisms and other antigenic proteins, whether coming from milk, serum, or pollens, is the outstanding defense in the immune state. The widespread prevalence of micro-organisms wherever life exists, and their constant contact with the surface tissues of animals, have produced the localizing mechanisms which aim ultimately not only to prevent invasion of the body, but also to destroy them locally in the area in which they happen to gain entrance. Tissue necrosis in pre-existing inflammatory tissue-antigen reactions was found to be a common immunologic phenomenon by Kahn. He pointed out that it has been seen clinically in infection when the wall which has kept micro-organisms localized in a given focus breaks down, resulting in their escape into the blood stream with a flaring up and necrosis in other pre-existing foci where the cells have become hyperimmunized.

Kahn[24] presented a hypothesis which fits the findings in a lethal granulomatous ulceration in the midline tissues of the face. He stated that through previous infections these naturally reactive tissues might have become hyperimmunized or might still remain nontoxic antigen. Tissue necrosis might then ensue from any specific or nonspecific nontoxic antigen circulating in the blood, possibly even from absorption of "anaphylactogens" through the intestinal wall. Lethal granulomatous ulceration of the nose, pharynx and larynx appears by preference in the midline region because this is a region made up of large areas of skin and subcutaneous tissue in juxtaposition with mucous membrane and submucous tissue. Such tissue has an innate capacity to develop hyperimmunity, possibly greater than any other area in the body. The body tends to respond to invasion by micro-organisms which are loma to localized allergic tissue reaction. It was shown by Ross[19] that an injection of staphylococcus toxin of varying dilution into immunized rabbits produced either a suppurative or granulomatous inflammation.

Cannon and Pacheco[20] demonstrated that after intradermal injection of living staphylococcus aureus into normal animals, edema of the subcutis with infiltration of polymorphonuclear leukocytes took place. In skin previously immunized, however, there was a heavy infiltration of lymphocytes and monocytes which became massed around a region of bacterial concentration ,and subsequently underwent necrosis with accompanying hemorrhage and thrombosis of the capillaries.

Arthus and Breton[21] demonstrated that if an area of skin is sensitized and antigen is then injected into the area, a pathologic picture similar to that produced in granuloma will result. Gerlach[22] in addition, described necrosis of the arterioles at the site of the Arthus phenomenon. Arkin[23] demonstrated the similarity in tissue reaction between periarteritis nodosa and granuloma, showing that the former underwent the same necrotic vascular reaction in somewhat larger vessels that caused the Arthus phenomenon when it involved capillaries.

Opie[24] observed that foreign protein injected in immunized animals became fixed at the site of injection, and it was in the immunized area that "anaphylactic" inflammation occurred. This anaphylactic inflammation histologically appeared indistinguishable from that seen in granulomatous inflammation. Finally, Wegener[25] reported a series of cases with pathological studies, where he found periarteritis nodosa to be a common finding in patients with lethal midline granulomatous ulceration. He felt that the condition causing the granulomata and that causing the periarteritis nodosa might be the same.

Kahn[26,27] and his co-workers at the University of Michigan have been engaged in experimental work on laboratory animals, attempting to demonstrate how allergic tissue reactions may lead to the development of lethal midline granuloma. Their work has given us the most direct explanation of the fatigue, or emotional conflict. This effect was produced by stimulation of the adrenotropic hormone of the anterior pituitary, which in turn stimulated the production of hormones of the adrenal cortex. He found evidence that such stimulation caused a relative adrenal cortical insufficiency. It, therefore, seems reasonable to assume that tissue immunity is a phase of the general adaptation mechanism and that hyperimmunity or bacterial allergy occurs in individuals who have a tendency toward relative adrenal cortical dysfunction. Under this hypothesis, "allergy" would have to be defined in the very broadest of terms.

Wegener[18] concluded that the vascular granulomatous and renal changes were manifestations of tissue hypersensitivity. He suggested that these lesions of lethal midline granuloma should not be separated from lesions found in disseminated lupus erythematosis which may show similar renal lesions, similar arteriolar necrosis and sometimes miliary granuloma.

Klinge,[29] in an experimental pathologic study of these related conditions described the pathological changes as a swelling of the ground substance of the vessels which are involved in the process, with edema, fibrinous degeneration and swelling of the collagen fibrils of the walls of the vessels. Klinge believes nonspecific lethal midline granuloma to be an allergic lesion which pathogenetically is related to rheumatic fever as well as to allergic vascular lesions such as periarteritis nodosa and lupus erythematosis.

Weinberg[30] feels that somewhat similar histologic pictures are seen in oidiomycosis, glanders, tularemia, leprosy, rhinoscleroma, blastomycosis and sporotrichosis, and effort must be made to rule out these organisms as causative agents. He also considered the possibility that a virus might be the causative agent, but stated that of the viruses, only that of venereal lymphogranulomata produces a microscopic picture which is similar. He believes that if these organisms are eliminated insofar as possible, periarteritis nodosa should be considered in the diagnosis. He presents evidence that lethal midline granuloma is an instance of localized hyperimmunity resulting in an Arthus-like reaction of the involved tissue.

meager producers of toxin principally by two "stereotyped" mechanisms, suppurative and granulomatous inflammation. In the first, the prominent responding cell is the polymorphonuclear leukocyte, in the second, the cells of the reticulo-endothelial system, especially the plasma cells and macrophages as local immunity develops.[11] In hyperimmunity states, there is an associated "capillary and lymphatic blockade" with the formation of central necrosis caused by cutting off the blood supply. This is essentially the Arthus phenomenon. Associated with the production of central necrosis is the production of areas of panarteritis in some of the smaller and larger arterioles. This is essentially periarteritis nodosa. It is presumed that the same mechanism working in different sized vessels produces both phenomena. It has been stated that idiopathic granulomatous ulceration and periarteritis nodosa together with rheumatoid arthritis, Lehman-Sacks syndrome, lupus erythematosis and other related conditions, are instances of vascular "allergy."[6]

Menkin[2] found that damaged tissue cells release a substance, necrosin, associated with Gamma globulin, that is capable of producing the central necrosis which Kahn did not explain adequately.

Although the concept of tissue immunity, as outlined by Kahn,[2] is not accepted by all immunologists, its development appears to have been made along logical lines of immunity versus hypersensitivity or allergy. In addition, it has furnished a practical working hypothesis for future research. Boyd,[2] in discussing immunity versus hypersensitivity, recognizes that "almost any kind of body cell can produce some antibody for local concentration." According to Landsteiner,[7] findings which suggest the possibility of local antibody formation in infected sites have been presented by Osterkov and Anderson, Tapley and associates, Sacks, Siegel and associates, as well as Cannon and associates. Williams states that from the viewpoint of phylogeny, Kahn's hypothesis seems highly probable.

Selye[4] presented evidence to indicate that periarteritis nodosa and related collagen diseases would also be produced by exposing an animal to such damaging stimuli as cold, well as necrotizing arteriolitis and glomerulonephritis, where the cause may be local tissue sensitivity ”

Hoover[illegible] stated that a typical pathological picture would show “ the border of the lesion an amorphous mass of necrosis, beneath which there is an infiltration by inflammatory cells, chiefly lymphocytes and macrophages with occasional plasma cells A few polymorphonuclear leukocytes are also present The large vessels show a definite perivascular cuff of lymphocytes and macrophages with degeneration of the arterial wall in some cases ”

McCart[32] found that after the initial proliferation of fibroblasts, “the polymorph aggregates disappeared and with the development of collagen, the (lethal midline granuloma) lesion resembled nonspecific granulation tissue, but behaved very differently because it was invasive When the granulation tissue reached a medium sized arteriole, it infiltrated all coats without destroying them When the granulation tissue had matured and become fibrous, a greatly thickened arterial wall resulted ”

It is evident that various pathologists, in presenting pathological descriptions of lethal midline granuloma, follow essentially the general picture of nonspecific inflammatory granulation tissue, showing no pathognomonic features Because of this lack of recognizable characteristics many lesions are grouped under this term which further study would yield more definite diagnoses

Prodda and Guenzi[34] reviewed the histological picture of several reported lethal midline granuloma cases, particularly in the German, French and Italian literature, and felt able to establish the diagnosis of malignant tumor of the reticuloendothelial system in these cases They state that the histological structures resemble various forms of sarcoma or one of the lymphomas Some of the neoplastic diseases suggested are Hodgkin's sarcoma, reticulum cell sarcoma, mycosis fungoides, lymphoepithelioma, and Kaposi's sarcoma DeFaria and his co-workers[35] reported three cases previously considered lethal midline granuloma which they were able to establish as reticulosarcomata The neoplastic tissue may present

PATHOLOGY

The pathology of the lethal midline granuloma does not have a specific character which would definitely differentiate it as a pathognomonic entity. Pathologists are cautious in reporting sections taken from lethal midline granulomas as being "not typical" or diagnostic of this or that condition, qualifying their impressions by admitting that their diagnoses, which range from granuloma, specific or nonspecific, to neoplasms, are atypical."[1]

The cells of the reticulo-endothelial system undergo successive morphological changes in granulomatous inflammation. These follow in order: proliferation, degeneration, death and dissolution, phagocytosis, mobilization and antibody production. The proliferative reaction is at times so enormous that the lesions often appear as tumors. This is thought to be responsible for the term "granuloma," introduced when the distinction between hyperplasia and neoplasia was not so sharply drawn as it is today. The abundant cells in the proliferative phase eventually disappear unless the inflammatory reaction is ineffective and the patient dies. Thus, necrosis of the reacting cells is characteristic of granulomatous inflammation.[11]

Pathological sections of lethal midline granuloma are generally described as showing broad zones of necrosis. Viable tissue, where present, is noticeably infiltrated by lymphocytes, plasma cells, some neutrophiles and eosinophiles, and with frequent histiocytes. The latter appear to form variable sized accumulations without the appearance of typical tubercles. Histiocytes and fibroblasts marginate zones of necrosis. Occasional mitoses are present, generally in histiocytic cells. As a rule, giant cells of foreign body or Langhans types are rarely evident. Necrosis is of infarct and coagulation types.

Boyd describes the microscopic appearance as "granulomatous in type with epithelioid cells, giant cells and lymphocytes, but the most striking feature is the intense necrosis resembling that of an infarct and possibly due to a marked degree of obliterating arteritis which accompanies the condition. Similar lesions are sometimes found in the viscera as

Such ulcerating carcinomas, leaving only small traces of intact tumor, are well known in the skin, where they have been mistaken for syphilis or other chronic granulomas, in the stomach, where they are mistaken for benign peptic ulcers [47]

In studying and reviewing the various neoplasms which may be masked by the lethal midline granuloma of the nose and face, the most likely types would include lymphoepithelioma, Hodgkin's disease, mycosis fungoides, and reticulosarcoma All but lymphoepithelioma of the nasopharynx offer valid objections in answering all requirements and fitting the clinical picture most consistently

Lymphoepithelioma[48] is the chief characteristic tumor of the nasopharynx in the younger and middle age group The histologic structure,[49] with its component of lymphocytes, easily lends itself to interpretation as an inflammatory granulatomous lesion when there are only small, distorted and partially necrotic remnants It is composed of a network of undifferentiated squamous cells, and in the meshes of this network are lymphocytes The two elements are always intimately related The neoplasm is generally of rapid growing nature and such tumors, as has been stated, tend to necrotize readily These tumors are also radiolabile so that moderate amounts of radiation therapy may suppress the neoplasm temporarily with accentuation of the necrosis and inflammatory base

One is impressed, therefore, with the fact that lymphoepithelioma of the nasopharynx, with its charatceristic location, consistent age grouping, and histologic structure, most closely resembles the necrotic ulceration seen in the lethal midline granuloma of the nose and face The tumor is found in structures which are anatomically and embryologically related [36, 50] Beyond the nasal and pharyngeal regions, it is found also in the tonsil, other portions of the hypopharynx, and base of the tongue, *i e*, where lymphoepithelioma tissue normally exists It is also the chief characteristic tumor of the thymus, another lymphoepithelial organ According to Arey,[50] the histogenesis of these structures from the second, third and fourth gill clefts relates them a "polymorphic structure with inflammatory-like cells such as lymphocytic, monocytic and plasma cells conspicuous in the tumor." They state that the matrix cell is the "undifferentiated mesenchymal cell (Maximow[2]), or the dedifferentiated macrophagic cell" which they found through vital staining. (Our American pathologists would probably call this a reticulum cell.) They quoted other reported cases of lethal midline granuloma which were subsequently shown to be malignant processes (Piquet,[7,8] Terracal,[9] Pirodda and Guenzi[11]). Piquet thinks that these tumors may originate as a reticulosis of the histiomonocytic type, but there are also mixed epithelial and gangrenous forms.

The improvement or cure of lethal midline granulomas with radiation therapy in cancericidal doses would support the neoplastic origin of many of the lesions reported. Terracal[9] collected eight cases from the literature, of which six were cured and two improved. Good results following cancericidal radiotherapy were also pointed out by Vilanova,[10] Causse,[11] Ellis[4] in two cases, Howell,[12] and Alajmo.[13]

TUMORS MASKING AS LETHAL MIDLINE GRANULOMAS

The ulcerative necrotic lesion appearing as so-called lethal midline granuloma may effectively mask a neoplastic process, as has been shown above (Pirodda and Guenzi,[11] DeFaria,[3] Terracal). This is not strange, because lymphoepithelial tumors in this location grow so quickly beyond their available blood supply that necrosis and ulceration takes place readily.[11] Because of their location in the nose and throat, secondary infection is inevitable. These factors combine to produce a necrotic base with a large inflammatory component in which only small residues or fragments of tumor can be found. The result is that these small aggregates of neoplastic tissue, obscured by areas of necrosis and inflammatory cell infiltration, are easily missed or misinterpreted in random biopsies. This is illustrated in Case 1 of our series, in which the biopsy was reported as nonspecific inflammatory granulation tissue. Subsequent biopsies, after the superimposed inflammatory infiltration subsided following Cortisone therapy, established the lesion as of neoplastic origin.

reports and diagnoses of our time are reviewed, similar reevaluations will be made and more specific diseases will be recognized. It is quite probable that lethal midline granuloma will then, with scientific certainty, be laid finally to rest.

CASE REPORTS

Case 1. A white man 33 years of age was first seen in consultation Sept 17, 1951 because of stuffiness in the left side of the nose and sore throat of about six months duration. He had lost about ten pounds in weight in the preceding two months and felt increasing fatigue at work. The past history revealed that he had a tonsillectomy three years previously and while in the Army six years before, he had been hospitalized for an involvement of the nose and throat. The personal and familial histories were not contributory.

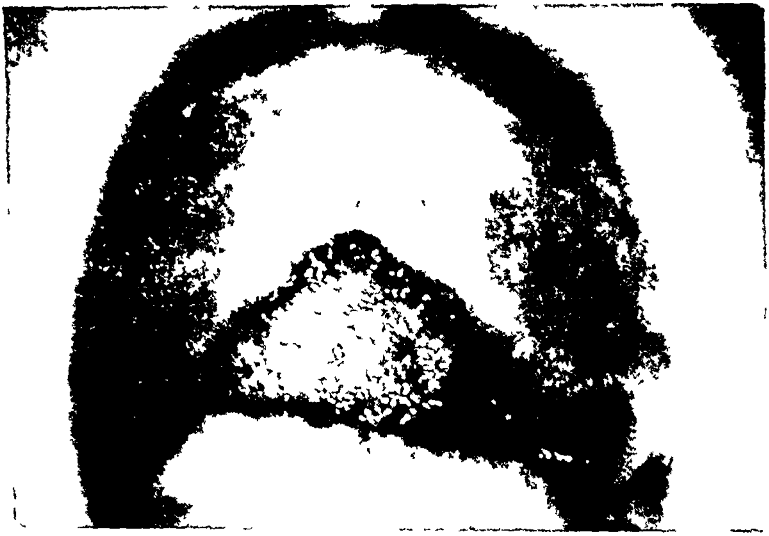

Fig 1 (Case 1)—Progression of destruction of palate and posterior pharyngeal wall

Examination revealed a thin afebrile normal appearing male in no distress other than that incident to the nose. A firm granulation was seen on the left inferior turbinate obstructing the nose and moderate edema of the soft palate was noted. The posterior pharynx behind the soft palate was red, moderately swollen and covered with a thick gray, purulent crust, there was no adenopathy.

The blood count showed no anemia and a relatively normal distribution of white cells. The Kolmer and Kline tests were negative for syphilis. Smears and cultures of the purulent exudate in the throat and nose were reported to contain staphylococcus aureus pneumococcus and streptococcus hemolyticus but were negative for acid fast bacilli

It would seem logical, then, that the lymphoepithelial structures, and the tumors derived from them, deserve to be regarded separately as an entity, and to be differentiated from the lymphomas on the one hand (Gottfriedson[2]), and from the non-keratinizing squamous cell carcinomas (formerly called "transitional cell carcinomas") on the other (Ewing,[3] Quick and Cutler,[4] Willis[1]). The European writers have long made this distinction; in the Orient, the tumor is well known because it is rather common (Mekis), and the concept has gradually been adopted in England and the United States. Trotter, in 1911, described clearly the characteristics of this tumor, and in 1921 Schminke and Regaud aptly named it lymphoepithelioma, a term which has remained in use. Capell, Harvey et al, Willis[1] and others have described its essential features.

The great variety of opinions, ranging from granulomatous inflammation of an unusual type to atypical neoplastic disease, illustrates the lack of pathological conformity and points to the heterogenous character which the term lethal midline granuloma embodies. Increasing awareness of specific causes, and reluctance in accepting the diagnosis of lethal midline granuloma except as a convenient tentative working diagnosis, will decrease the number of cases acceptable as idiopathic. Thus, in reviewing older reports, such destructive facial granulomas considered idiopathic at the time of their publication, seem to be attributable, in the light of present knowledge, to more specific causes. Fordyce reported a "case of undetermined tropical ulcer" in a native of Central America which strongly suggests the possibility of American Leishmaniasis. A case of Henry Macnaughton Jones was considered by the discussants as factitial, and the author had, himself, entertained that possibility. Similarly, Naborro's report of an 11-year-old girl whose condition was cured in 11 days by the oral administration of extract of the common alder may have been factitial. Occasionally, other rare occurrences may lead to somewhat similar clinical pictures, as in the case of a foreign body granuloma of the nose due to gauze left following an injury (Pearlman).

It is, of course quite likely that in future years when case on the pharynx, and a similar necrotic slough was noted over the left inferior turbinate of the nose

On Oct 25, 1951 Cortisone was begun with 300 mg daily and was gradually decreased to a maintenance level of 100 mg daily Improvement was noted the next day and continued until the gray slough disappeared and the ulcerated borders began to show healing The patient's general health improved and his mental attitude indicated more optimism

A biopsy specimen taken Nov 6, 1951, was reported that with subsidence of the inflammatory cells, the principal cell involved had a more epitheliomatous appearance and frequently exhibited large nuclei and occasional mitotic figures Consultative opinion now favored a diagnosis of lymphoepithelioma The tissue was extensively necrotic and abundant lymphocytes obscured the epithelial framework making diagnosis difficult

After improvement lasting almost three months, the palatal and nasal ulceration and necrosis again became evident The process became rapidly destructive and another biopsy was performed A diagnosis of atypical lymphoepithelioma was made and was confirmed by still another biopsy, as lymphoepithelioma

In view of the deteriorating condition and massive destruction, cancericidal radiation therapy was started through an intraoral cone measuring 3 5 cm in diameter, a right and left lateral nasopharyngeal port measuring 10 cm in diameter and a right and left antral port measuring 5 cm in diameter Over a period of approximately 33 treatment days, dating from Jan 25 1952, to Feb 18, 1952, the patient received an estimated tumor dose of 4855 Roentgen units measured to the midline of the palate Progress biopsy reports showed tumor cells undergoing excellent radiation effects and encouraged radiation therapy to the limits of tolerance He was given an additional 1000 Roentgen units measured in air delivered through each antrum, directed toward the midline until Feb 29, 1952 There was an initial increase in the swelling and destruction, but this disappeared after a few days After this his reaction to the radiation therapy was uneventful and on April 11, 1952 the reaction had completely subsided no visible evidence of residual disease was noted although the defect in the palate persisted

The palatal lesion showed slow but progressive healing until the gray crusting and ulcerated edges became smooth and free of exudate He has been observed regularly since and has resumed his work His last visit to our office for observation on Nov 8 1956 more than five years since the onset of the lesion, showed the patient to be in good health with no evidence of recurrence

Comment This case illustrates how the underlying neoplastic process was masked by necrosis and chronic inflammatory cells Cortisone was given to this patient when its administration was new and its effects still uncertain When the diagnosis of neoplasm became apparent with succeeding biopsies, it was thought that the Cortisone may have caused the metaplasia from chronic granulation tissue We consulted various sources, and Dr Henry Williams expressed the opinion that we might be dealing with a Krompecker epithelioma He stated that at the Mayo Clinic, great difficulty was encountered at times in differentiating this type of tumor from a

Guinea pig inoculation subsequently failed to show acid fast bacilli. Skin tests for coccidioidin and histoplasma were negative. A biopsy specimen from the left nasal turbinate was reported as "chronic granulomatous rhinitis." The pathologist noted "... chronic inflammatory reaction in a tissue which is covered by a slough. Although occasional foamy cells are seen in the chronic inflammatory reaction, the general pattern does not fit that ordinarily seen in scleroma. There is no suggestion of neoplasm in this tissue." X-ray report indicated hyperplastic sinusitis without bony involvement. The chest film showed normal findings.

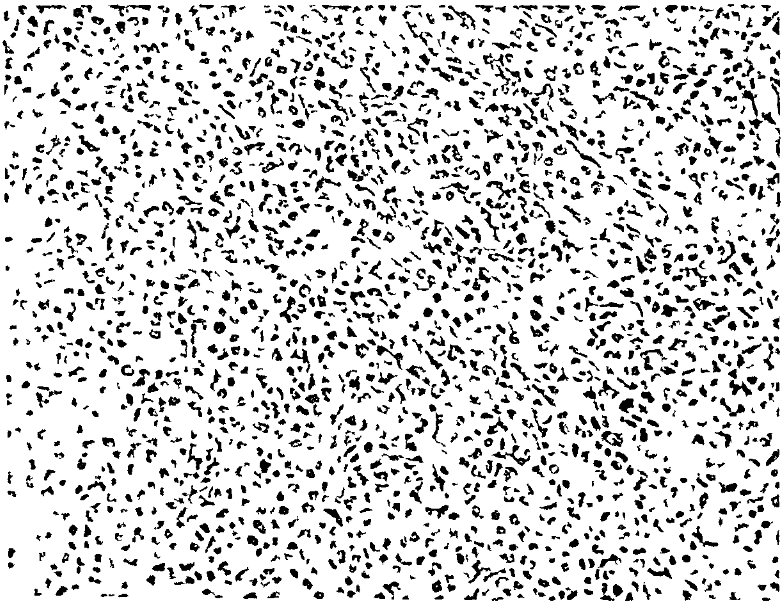

Fig. 2. Section of nasal lesion after subsidence of inflammatory exudate showing principal cell larger and more epitheliomatous in appearance with mitotic figures.

The patient was given penicillin intramuscularly and sulfadiazine orally as well as bacitracin ointment locally. The condition did not show any improvement. A week later a gray necrotic area appeared on the soft palate and spread rapidly until the central portion of the soft palate excluding the uvula was involved. An ulcerated sloughing area developed in the center of the necrotic patch. Another biopsy was done to include the ulcerative border of the lesion. This was reported as "... deep invagination surrounded by epitheliomatous outcroppings which because of its arrangement and appearance is considered to be a pseudo-epitheliomatous hyperplasia." The pathologist noted a chronic inflammatory cell infiltration with a granulomatous blood vessel pattern.

The patient was continued on penicillin 600,000 units daily; streptomycin in 0.5 Gm doses was added, and terramycin was substituted for the sulfadiazine. The destructive ulceration progressed until about half of the soft palate was destroyed. A gray sloughing ulcer was present on the pharynx and a similar necrotic slough was noted over the left inferior turbinate of the nose

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Case 2. This 27 year old white woman was first seen at the Los Angeles County Hospital on Dec. 8, 1949. She complained of persistent sore throat of six weeks duration. She had been treated by her family physician with throat irrigations and penicillin but had shown no improvement. Her past history revealed that she had had epileptiform seizures since childhood. The familial and personal histories were not pertinent. There was no contact with tuberculosis or coccidioidomycosis.

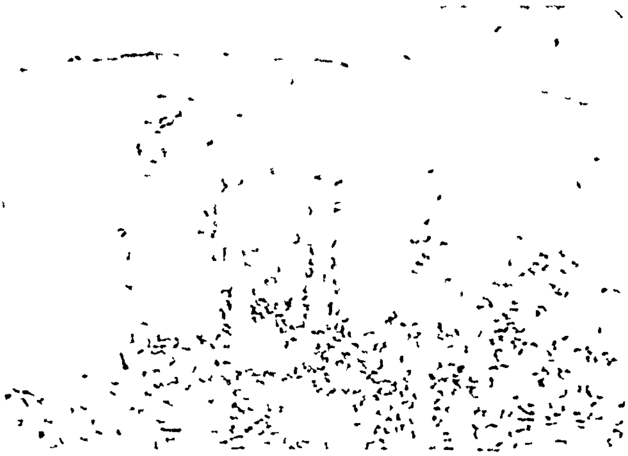

Fig. 2 (Case 2).—Section obtained from nose showing chronic inflammatory infiltration (×125).

Physical examination on entry disclosed the patient to be a well developed thin white woman who appeared in good general health and was afebrile. The relevant findings consisted of a small granulomatous lesion with a 1 cm. perforation on the soft palate near the base of the uvula. There was a midline area of erosion of the hard palate covered by a tenacious gray exudate. The left side of the nose was obstructed by a red swollen area along the floor and septum which bled easily on slight trauma.

Laboratory studies showed a blood hemoglobin concentration of 11.8 Gm. per 100 cc., 4,000,000 erythrocytes and 6,500 leucocytes per cubic millimeter, with a normal differential count ratio. The serologic test for

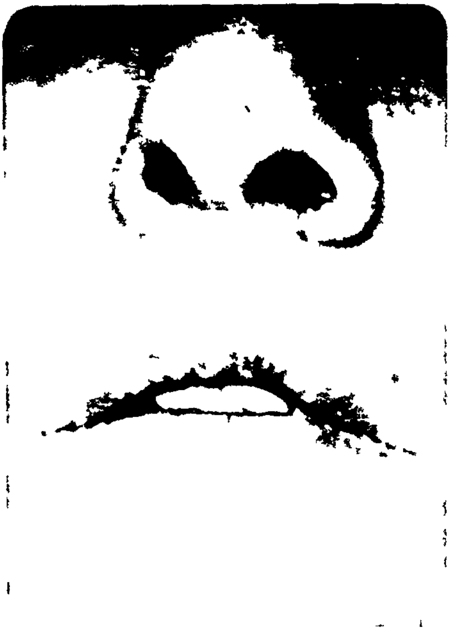

Fig 4 (Case 2)—View of mass on left side of nose at base of septum

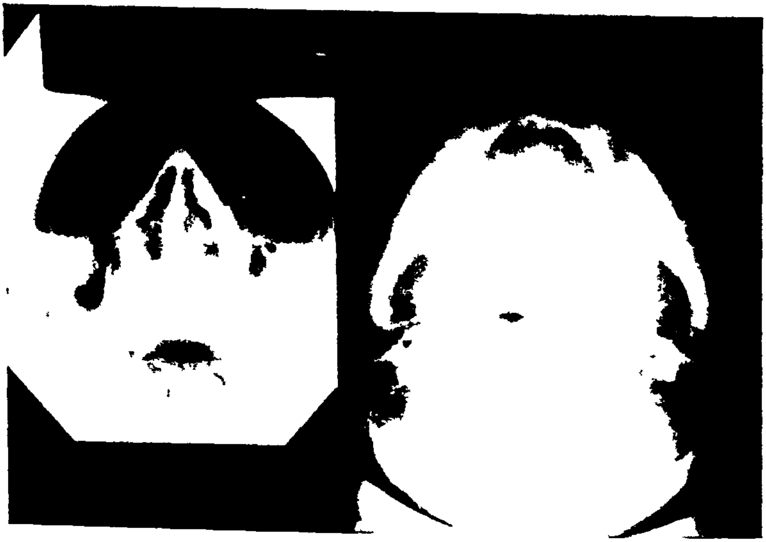

Fig 5 (Case 2)—Roentgenogram showing opacity involving left half of the nasal cavity and the base of the septum causing deviation and obstruction

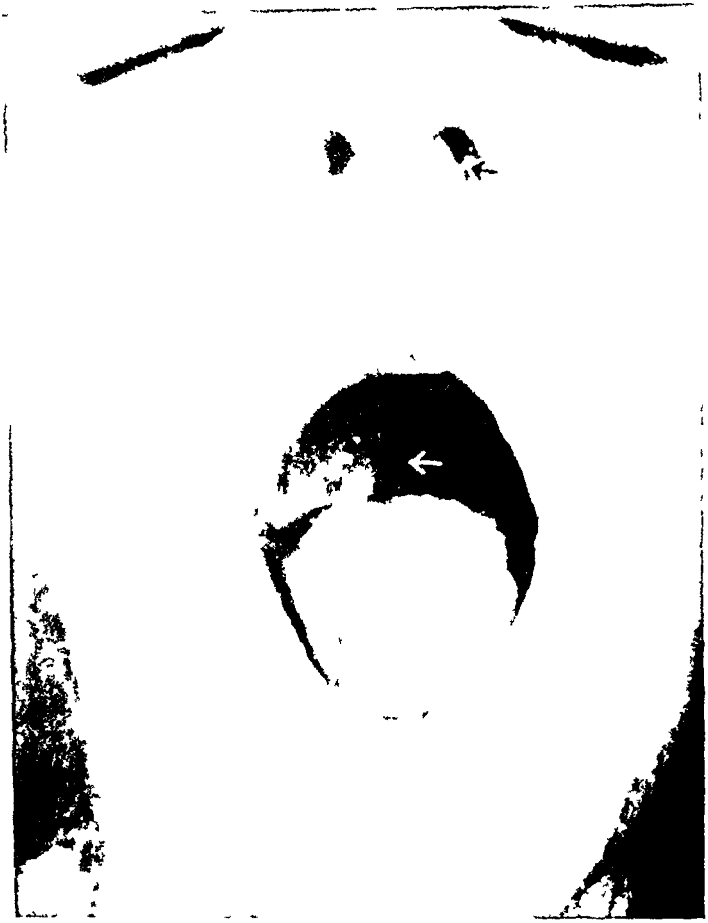

Fig 6 (Case 2)—Granulomatous mass on nasal septum and ulcerating granuloma on palate six months after onset of illness

syphilis the complement fixation tests for coccidioidomycosis and the serum agglutination test for typhoid paratyphoid brucellosis tularemia and cold agglutinins all showed negative results No sugar or albumin was present in the urine Examination of the cerebrospinal fluid disclosed no abnormal findings Tuberculin coccidioidin histoplasmin and Frei skin tests gave negative results No acid fast bacilli were found on nasal palatal and sputum smears and cultures of the palatal lesion showed candida albicans on two occasions but no other fungi were ever found Repeated aerobic and anaerobic cultures revealed streptococcus viridans and staphylococcus albus

She was given penicillin 300 000 units intramuscularly daily for prolonged periods up to a total of 27 000 000 units streptomycin 2 Gm daily later reduced to 1 Gm daily intramuscularly for about three weeks, aureomycin 1000 mg orally every day for one month saturated solution of potassium iodide orally, 30 to 90 minims daily in divided doses for two weeks (because of findings of candida) and antimony in the form of Fuadin, 5 cc intramuscularly, three times weekly for three weeks (because of similarity to anaerobic streptococci lesions)

There was no response to any of the medication The soft and hard palates became ulcerated, necrotic and finally a perforation resulted A biopsy specimen taken from the soft palate on Jan 6 1950, was diagnosed as "granulation tissue—nonspecific" A splenic smear examined for histoplasma capsulatum showed no organisms Complement fixation tests and cultures for rhinoscleroma gave negative results X ray examination of the nasal bones and sinuses showed an opacity involving the left half of the nasal cavity, with the septum and tip of the left nasal bone deviated to the right On a lateral view of the nasopharynx, a circular tumefaction was noted just anterior to C_1 and another tumefaction bulging in the epipharynx and posterior choanal region

Another biopsy specimen was obtained March 3, 1950, resulting in a diagnosis of "granulation tissue with overlying mucous membrane—probably an infectious granuloma" In the middle of June, the destruction of the palate extended into the posterior choana nasopharynx and septal region The turbinates were swollen and bled easily The fever became of septic type reaching 104° at times Convulsions, diagnosed as of the Jacksonian type, became more frequent and occurred as often as several times a day The patient had lost about 60 pounds during the preceding six months The course was progressively downhill, and she became mentally cloudy during the last three days of life The patient expired approximately 10 months after the onset of her throat symptoms

Postmortem examination of the nasopharynx, soft palate and nose revealed most sections to be necrotic, but one section showed a tumor composed of small cells near the size of monocytes supported by a delicate fibrous reticulum There were many mitotic figures Other areas of the same mass showed characteristics of transitional cell tumors It was the opinion of the examining pathologist that this was definitely a tumor with secondary infection, rather than a granuloma

Comment This case illustrates pointedly the need for deep and thorough biopsies The secondary infection and necrosis thoroughly masked the underlying neoplasm It is possible that if Cortisone had been available at the time, the inflammatory reaction may have subsided enough to facilitate recognition of the neoplasm

Case 3 A 34 year old colored male with a history of a "painful sore" on the roof of the mouth of two weeks' duration, was seen at the Los Angeles County Hospital, Jan 28, 1954 He stated that he may have scratched the roof of the mouth with his finger He felt "feverish" and experienced chills and fever at the onset The pain was dull aching in character and was associated with a feeling of fullness and aching in the neck The chills and fever recurred every night, and the mouth pain became progressively worse He gave a past history of alcoholism of about 10 years' duration Two years prior to his present hospital entry he had a bout of gastro intestinal symptoms characterized by a steady gnawing pain over the epigastrium which was relieved by food In addition, in the past three years he had a productive cough which he attributed to smoking He had a negative minifilm examination of his chest taken by a mobile unit three years previously A luetic infection was present when he entered the Army in 1944 He was given a six-

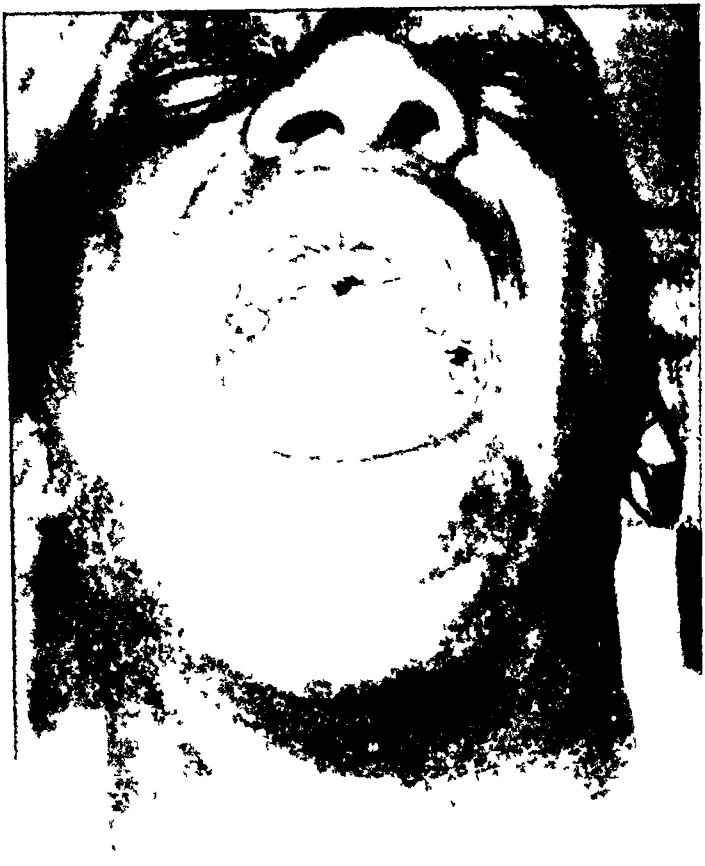

Fig. 7 (Case [illegible]).—Photograph of palate showing ulceration and necrosis three weeks after onset.

month course of treatment and told that he was cured. Subsequent blood tests proved negative for syphilis.

Examination revealed a well nourished Negro male with a temperature of 99° F. in no distress. An irregular white necrotic area measuring about 4x4 cm. was seen over the hard palate extending through the mucous membrane and further extending by perforation into the nasal cavity. A few movable shotty nodes were present bilaterally in the neck. Several carious teeth were noted in the mouth and an old scar over the cheek. The other physical findings did not reveal any abnormalities.

X-ray of the chest and face showed no bony abnormalities except for a defect in the hard palate. X-ray examination of the gastrointestinal tract showed a shallow ulcer on the lesser curvature of the stomach. A complete blood count showed a normal number of erythrocytes and white blood cells with a normal cell distribution Stain and culture of his sputum showed no acid fast organisms Urinalysis was negative for albumin or sugar Smear and culture of the lesion showed Gram positive cocci and Gram negative bacilli, but no acid fast or diphtheria bacilli The heterophile antibody agglutination was negative No fungi were grown in culture, and skin tests for coccidiomycosis were negative Blood sugar determination did not indicate evidence of diabetes The Kolmer and Kahn tests were both negative, and a spinal fluid examination also resulted in a negative serological reaction for syphilis A biopsy specimen of the lesion showed "nonspecific chronic granulation tissue without evidence of malignancy" The pathologist believed the lesion to be consistent with a "diagnosis of a so called midline granuloma"

The patient was given tetracycline 2000 mg daily for five days without demonstrable improvement He was then placed on 1,200 000 units of penicillin and streptomycin 1 Gm daily At the end of two weeks, the lesion continued to show progressive destruction and a slough fragment of necrotic ulceration was again examined for micropathological diagnosis smear, and culture The microscopic examination showed "nonspecific and necrotic granulation tissue" Smear and culture showed a mixed staphylococcus and streptococcus flora

In spite of the gastric ulcer, and in view of the grave prognosis of a lethal midline granuloma the patient was placed on 50 mg of ACTH intramuscularly daily He was given potassium chloride 15 grams daily and placed on a low salt diet No activation of the ulcer took place, and the amount of ACTH was increased daily, first to 120 mg intramuscularly and finally after he had been on intramuscular administration for 10 days, he was given 120 mg ACTH intravenously in 1000 cc of 5 per cent glucose continuously over a 24 hour period for four days Uropepsin content of the urine was checked before and after the intravenous infusions to check activation of the gastric ulcer Intramuscular injections of ACTH in 120 mg daily doses were then resumed The patient began to show improvement within the first week after ACTH was administered but demonstrated more rapid healing coincident with the intravenous administration Epithelialization became evident, and the defect began to fill in slowly over the next three-week period His general condition was greatly improved and he was transferred to the Veterans Hospital where he continued to take the ACTH

Our last reports from the Veterans Faculty were that the palate defect finally filled in and he was discharged six weeks later feeling well An attempt was made to contact him this year but his present forwarding address is unknown

Comment The lesion in this patient showed no response to antibiotics, but improved dramatically with the corticotropins This would indicate that the lesion is probably of the group associated with "allergic" tissue changes related to the collagen disease although no vascular changes were seen in the biopsy specimens It is also of interest that the gastric ulcer found in this patient would also be associated with stress, and may show some relationship in response to the cortico-steroids

Case 4 A white male, 42, was first seen in February, 1951, with a presenting complaint of swelling and discomfort of the right lower jaw bicuspid region He stated that this followed the use of a penicillin troche a week previously, after which the swelling "spread like wildfire." The remainder of the right lower jaw was involved and pain became severe and widespread over the face. He gave a past history of duodenal ulcer at the age of 6 with hemorrhage. He had undulant fever at the age of 1. Otherwise the patient had always been in good health and was athletically inclined until about five months prior to the present onset, when he felt weak and listless.

He was first admitted to St Vincent's Hospital on March 19, 1951, because of swelling of both upper and lower gums and hemorrhagic eruption over the alveolar mucosa. The red blood count was 5,400,000, and the white blood count 7,500 per cubic millimeter with a normal cell distribution. The platelets appeared normal in number and morphology.

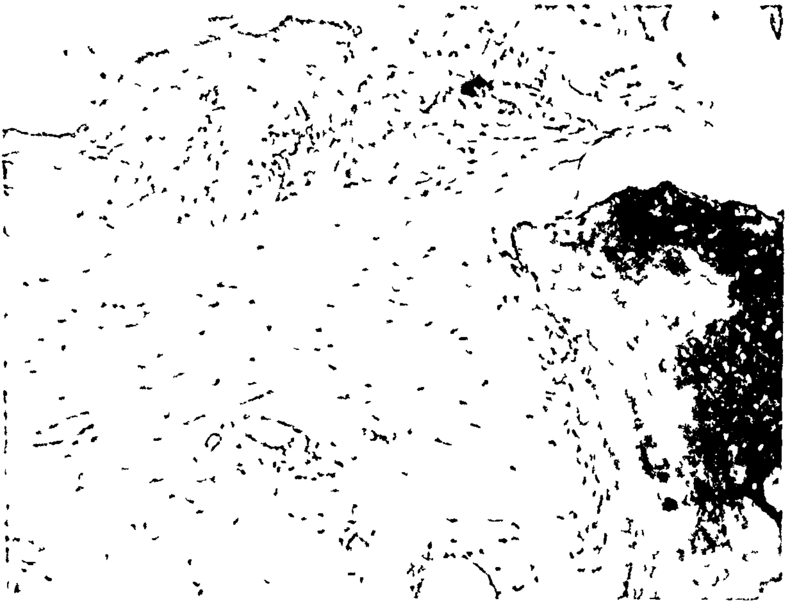

Fig. 8 (Case 1).—Section of mastoid obtained at autopsy (×125) showing scattered microabscesses surrounded by fibroblasts and a dense exudate of plasma cells, lymphocytes and large number of macrophages.

The blood culture was negative after 18 hours, and the agglutinations for Brucella were negative in all dilutions. Biopsy of the gum tissues showed a suppurative inflammatory process without definite bacteriologic diagnosis. He was given aureomycin 1000 mg. daily and streptomycin 1 Gm. intramuscularly daily. The febrile reaction and pain subsided but did not entirely disappear. He was discharged from the hospital and continued under observation in the office.

The condition grew steadily worse, and he was readmitted to the hospital on April 18, 1951. The oral surgeon in attendance noted at this time that the gums were dark red and swollen. Miliary abscesses were distributed over the surface. The patient noted pain in the ears with increasing deafness on both sides. The otological consultant found no gross changes in the ear. The deafness was of the mixed type and ranged from 32 per cent on the right to 42 per cent on the left in air conduction, 25 per cent on the right and 10 per cent on the left by bone conduction Biopsy at this time showed multiple punctate abscesses with chronic round cell infiltration and fibroblasts in the submucosa There was no primary vasculitis or specific pathognomonic pattern He was maintained on tetracycline antibiotics with only slight regression of the lesions

On June 4, 1951, he was placed under the care of an internist and admitted to the hospital for a complete and comprehensive examination At this time, it was noted that along with the gum lesions he had generalized skin sensitivity, and a weakness of the left side of the face became evident The patient felt weak and had an irregular fever ranging from 100° to 106° F A diagnosis of possible Reiter's syndrome was made It was felt that one of the collagen diseases (particularly periarteritis nodosa), lymphomas and leprosy should be ruled out Nasal scrapings were examined for leprosy and repeated smears and cultures did not yield any spcific incriminating organisms Both ears were found to be draining a mucopurulent secretion It was the otologist's opinion that this was due to the systemic process causing swelling throughout the upper air passages and including the Eustachian tubes An X ray of the sinuses showed minimal haziness in the sphenoids and right antrum

The antibiotics were stopped and he was placed on ACTH therapy This resulted in improvement of the mouth lesions and he was discharged from the hospital He continued on ACTH, while at home receiving injections of 80 mg daily After three weeks it was found that the response to ACTH was fair, but dosages under 100 mg daily resulted in exacerbation

He was readmitted to the hospital for neurological examination including a spinal tap because of increasing headache and pain over the face The neurologist confirmed the findings involving the VIIIth nerve deafness and VIIth nerve facial palsy, which he felt were peripheral in type and due to compression He came to the conclusion that the condition fit most consistently as a part of collagen disease involvement rather than a specific neurological lesion

An epidemiologist in consultation felt that there was no Hansen's disease or Steven Johnson syndrome Hematological consultation and bone marrow study revealed reactive marrow without evidence of neoplasm There was a remission in his symptoms of pain and he was discharged home

On Aug 7 1951, the patient experienced severe epigastric pain nausea and vomiting, and was readmitted to the hospital The facial palsy persisted and the headaches continued in increasing severity In the course of his examination the blood chemistry determination blood count and clotting time all proved to be within *normal limits* A peritoneoscopy was performed and showed no conclusive results The abdominal symptoms subsided, but the pain over the face and head increased There was tinnitus and a "dizzy swirling sensation" It was obvious that the patient's condition was steadily growing worse An exploratory craniotomy was performed on Oct 19 1951, and the left cerebellopontine angle was explored No space occupying lesion was seen but granulation tissue was noted in the region of the VIIth and VIIIth nerves Some of the granulations were removed for histological diagnosis The patient did not rally, becoming increasingly comatose, and finally expired with a terminal fever of 106° on Oct 22, 1951

Postmortem examination showed granulomatous tissue distributed in the nose paranasal sinuses ears meninges, kidneys and prostate In the brain the granulomatous process was limited to the dura and small

second biopsy of the palate and nose was diagnosed as "nonspecific granulation tissue and necrosis without evidence of malignancy The findings are consistent with a midline granuloma"

The ulcerative process continued to destroy the palate, causing the loss of the entire soft palate and about a third of the hard palate The floor of the nose remaining septum the nasopharynx and the palate appeared to be invaded by an indurative firm, gray pink irregular tumor which almost filled the nasopharynx and posterior nares An extensive and deep biopsy specimen from the palate, nose and nasopharynx was examined by several pathologists The microopathological diagnosis of the lesion was given as 'typical of Ackermann's verrucous carcinoma' This was described as a non metastasizing locally invasive malignancy The intensive antibiotic therapy helped to clear the secondary infection and relieved the throat soreness and painful swallowing but it did not affect the destructive course of the lesion

He was observed in the clinic without his showing any improvement X-ray therapy was given in weekly doses from May 28 1951, to Oct 12, 1951 At the end of the course of X-ray treatments it was felt that the lesion had regressed partially, and the patient was asymptomatic In the course of the next month the destructive process appeared active again with increasing soreness of the throat and painful swallowing

He was again admitted to the hospital and was placed on ACTH therapy, however, this had to be stopped after four days' administration because of marked increase in blood pressure to 270/140 and left congestive heart failure The administration of digitalis low salt diet and ammonium chloride gradually helped and he was discharged home A biopsy at this time was diagnosed as 'pseudoepitheliomatous hyperplasia with evidence of Ackermann's verrucous carcinoma '

In the following four months, the patient showed progression of the lesion and had numerous admissions to the hospital During one admission he was placed on bismuth subsalicylate and potassium iodide as a therapeutic test for lues, but he did not show any *improvement* The lesion progressed until it involved the whole nasopharynx hard palate and posterior half of the nose He had frequent episodes of nasal bleeding, developed ankle edema and orthopnea He died of a terminal bronchopneumonia

An autopsy could not be obtained

Comment In this case, the diagnosis of lethal midline granuloma was established on the basis of preliminary biopsies which showed nonspecific granulation tissue Aided by the intensive antibiotic therapy which cleared the secondary infection, it was possible, with subsequent extensive and deep biopsies, to establish the diagnosis of an atypical neoplastic lesion Unfortunately, this type of tumor was not susceptible to X-ray therapy and not amenable to surgery

Case 6 This 62 year old Negro man presented himself to the Otolaryngological Clinic of the Los Angeles County Hospital on March 30, 1949 He gave a history of increasing difficulty in breathing through the nose for the past three months His past history included a hospital admission in 1937 for pulmonary tuberculosis At that time note was also made of hypertension and early cardiac enlargement He was under observation by the Health Department and was discharged as an arrested and inactive case of tuberculosis There were no further manifestations of acid fast infection

Examination revealed a thin afebrile Negro male in no distress A large fungating mass was seen originating on the floor of the nose at the anterior portion of the septum This mass extended from the anterior septal area to the posterior choana on both sides It was friable and bled easily His other general findings indicated a moderate hypertension and enlarged heart without evidence of decompensation

Serological tests for syphilis were negative X ray of the chest although showing extensive scarring from the old infection did not show any presently active process Sputum studies and culture showed no acid growth Repeated subsequent biopsies showed chronic granulomatous inflammatory tissue with small tubercles and giant cells

There were numerous visits to the clinic for observation, but no improvement was evident The chest consultant was of the opinion that the lesion was of tuberculous origin, even though acid fast bacteria were not found Local injection of streptomycin was advised In October, streptomycin was injected directly into the lesion in 0 5 gram doses daily for a total of 9 0 grams There was prompt subsidence in the size of the swelling and the patient was able to breathe easier It was the consensus of the staff that this effect was due to the streptomycin acting specifically on the granuloma which was of tuberculous origin

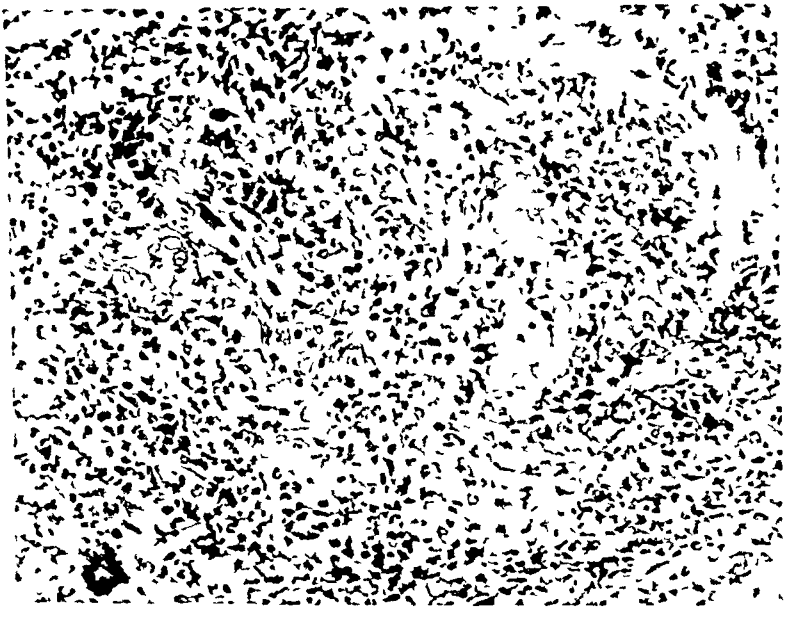

Fig 10 (Case 6)—Photomicrograph of nasal lesion (X285) showing chronic granulomatous inflammation In some areas giant cells and granulomatous epithelioid elements with small tubercle formation can be seen

He was observed in the clinic and by a private physician with no recurrence of the swelling Two years later the patient suffered a terminal cerebrovascular accident and was hospitalized Examination of the nasal lesion at that time showed an adequate airway with no recurrence of the swelling

Comment This case was of great interest to the staff because of the tuberculous character of the nasal lesion and the effect of the streptomycin injected locally Acid-fast organisms were never found but streptomycin appeared to act with the specificity expected usually only in active infection

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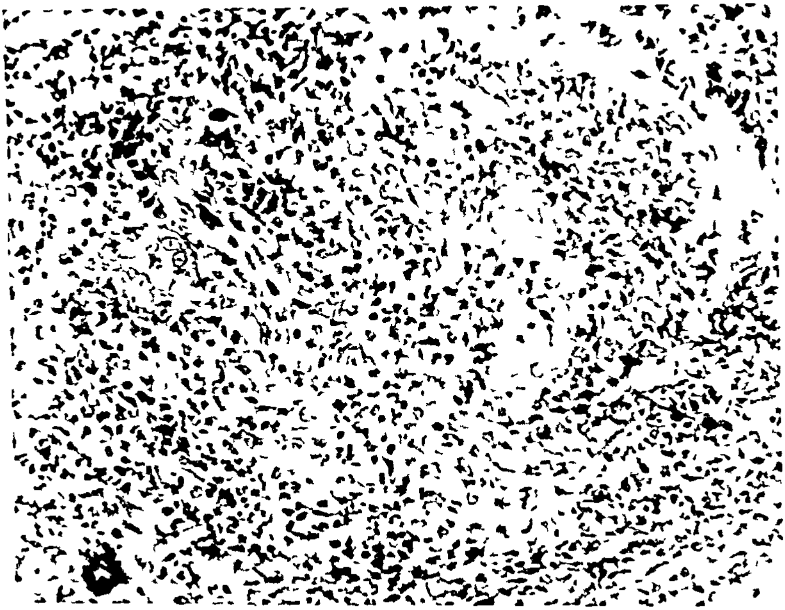

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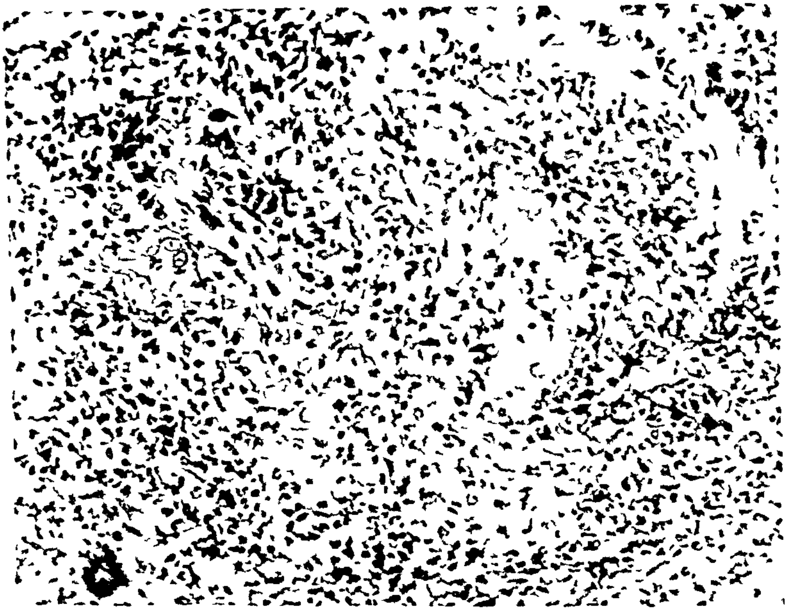

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Case 7 This white male age 32, was first seen in the office on July 25 1955 He gave a history of recurrent pain over the left cheek and in the left nostril for two weeks This was associated with a feeling of constriction in the left side of the nose and pressure over the left side of the cheek For the preceding few months he had occasionally blown a large crust from the left nostril There was no known allergy and he had never taken antihistamines

The past history revealed no nose symptoms until 1945 when he experienced pain in the cheek and nose after swimming in a salt water pool while in the Service in the South Pacific He consulted a flight surgeon who told him that there was nothing wrong He recovered from this episode, but in the succeeding years he had recurrent attacks of nasal blocking, mainly on the left and pain over the left cheek He noticed these symptoms in the preceding three years as occurring particularly in the springtime He consulted several ear nose and throat specialists but they were unable to find anything wrong

Examination revealed the left middle turbinate covered with a firm and adherent white membrane When this was scraped loose the underlying mucosa was very pale There was no bleeding Purulent discharge drained from the left middle meatus The right nasal passage showed no abnormalities Nasopharyngoscopy revealed purulent discharge on the left posterior pharyngeal wall The left antrum did not transmit light well on transillumination

X rays showed no evidence of sinus disease Smear and culture showed a pure growth of E coli and staphylococcus aureus Slight sensitivity was shown by the organisms to streptomycin aureomycin achromycin and terramycin but resistant to gantrisin sulfadiazine erythromycin and penicillin neomycin and polymixin B Gram stain showed a few epithelial cells and polymorphonuclear leucocytes a few gram positive cocci in pairs and rare diphtheroid bacilli

The patient was placed on achromycin A biopsy was attempted in the office but the patient exhibited syncope, and the procedure had to be terminated He was hospitalized and a biopsy specimen was obtained of the left middle turbinate The section demonstrated all the tissue to be inflammatory with no normal epithelium or other preexisting structures in evidence The cells present were necrotic leukocytes In other areas there was a necrotic fibrinous zone beneath which there was inflammatory exudate This consisted of lymphocytes plasma cells rare neutrophiles and small blood vessels No fungus structures were present A few nodular foci of necrosis occurred but this was not accompanied by cellular features of granulomas which produce tubercles'

A diagnosis of "necrotic inflammatory tissue etiology not apparent" was made by the pathologist who commented that the biopsy specimen was not diagnostic and that changes present were not those of scleroma They were more consistent with a necrotising inflammatory disease such as diphtheria, Vincent's angina agranulocytosis and chemical injury Diphtheria was excluded by smear and culture

The blood count showed a leukopenia (4 800) with a relatively normal white cell distribution The red blood cells numbered 4 700 000 with 14 1 Gm hemoglobin and showed no atypical morphological forms The platelets were normal in number The Kolmer and Kline tests were both negative,, and the tuberculin skin test was negative

On Aug 15, 1955, the patient showed no improvement His internist suggested administration of meticorten to rule out the possibility of a collagen vascular disease At the same time he was continued on achromycin to lessen the purulent discharge

On Sept 1, 1955, he was hospitalized because of a fever of 105°, purulent discharge from both sides of the nose right otolgia and the appearance of gray necrotic area over the hard palate to the right of the midline During his hospital stay, the palate lesion progressed to ulceration and finally perforation into the right nostril A biopsy specimen of the palate lesion revealed "chronic granulation tissue consistent with a lethal midline granuloma ' X-rays of the sinuses at this time showed almost complete opacity of the antra and ethmoids A Hotchkiss McManus stain for fungi was done with special reference to histoplasmosis and this resulted in negative findings, the blood cultures showed no growth Repeated smears and cultures did not yield any new diagnostic information Blood sugar was 85 mg and the non protein nitrogen was 22 Complete viral studies for murine typhus, Rickettsial pox, Psitt LGV group and Q fever were negative The patient was given large amounts (1,200,000 units) of penicillin daily along with meticorten and achromycin His temperature went done to normal, and he felt well enough to be discharged

One week later on Sept 28, 1955 he was readmitted because of profuse bleeding from the palate lesion and a daily elevation of temperature to 100° F and over It was noted that in addition swelling and tenderness was present over the right malar bone During his hospitalization, recurrent bleeding from the palate was noted, associated with progression of the local lesion He had a daily spiking of temperature to 103° and over in spite of antibiotics, Cortisone and ACTH Repeated blood cultures showed no growth A drop in the white cell count to 2,500 per cubic millimeter with 71 per cent neutrophiles was noted, and a prolonged prothrombin time of 22 The bleeding was controlled by suturing the palate, and the patient was given transfusions of 500 cc of citrated blood on Nov 12 and 15, 1955 The fever became more septic and spiking in type, terminating at 105° with his death Nov 18, 1955

Postmortem examination revealed the sinus lining to be hyperplastic with a few plasma cells and lymphocytes in the subepithelial layers The bone of the right antrum was necrotic and surrounded by marked fibroblastic activity and inflammatory exudate No granuloma or tumor was seen The liver, spleen and kidneys did not show any granulomata or vascular changes

Comment This case exhibited almost total lack of resistance This was consistent with the microscopic findings of tissue from the right antrum, which exhibited extensive necrosis with virtually no inflammatory exudate The terminal leukopenia gave added evidence of the total exhaustion of the defense mechanism

Case 8 A white male, aged 36, was admitted to the Santa Fe Hospital on Nov 3, 1955, with a history of an upper respiratory infection one year previously, which was followed by a nasal stuffiness on the right side Bouts of respiratory infections sinusitis, and purulent nasal discharge recurred during the year The right nasal obstruction became progressively worse and was associated with occasional bleeding Except for weight loss of 20 pounds during the preceding year, the history was not significant

Physical examination showed a thin but otherwise normal male Temperature was 98 8° F The right side of the nose was blocked by a friable, irregular mass which bled easily and involved the right side of the septum the ventral and lateral walls of the nose Pus was present on

Case 7 This white male age 32, was first seen in the office on July 25 1955. He gave a history of recurrent pain over the left cheek and in the left nostril for two weeks. This was associated with a feeling of constriction in the left side of the nose and pressure over the left side of the cheek. For the preceding few months he had occasionally blown a large crust from the left nostril. There was no known allergy and he had never taken antihistamines.

The past history revealed no nose symptoms until 1945 when he experienced pain in the cheek and nose after swimming in a salt water pool while in the Service in the South Pacific. He consulted a flight surgeon who told him that there was nothing wrong. He recovered from this episode but in the succeeding years he had recurrent attacks of nasal blocking, mainly on the left and pain over the left cheek. He noticed these symptoms in the preceding three years as occurring particularly in the springtime. He consulted several ear nose and throat specialists but they were unable to find anything wrong.

Examination revealed the left middle turbinate covered with a firm and adherent white membrane. When this was scraped loose the underlying mucosa was very pale. There was no bleeding. Purulent discharge drained from the left middle meatus. The right nasal passage showed no abnormalities. Nasopharyngoscopy revealed purulent discharge on the left posterior pharyngeal wall. The left antrum did not transmit light well on transillumination.

X rays showed no evidence of sinus disease. Smear and culture showed a pure growth of E coli and staphylococcus aureus. Slight sensitivity was shown by the organisms to streptomycin aureomycin achromycin and terramycin, but resistant to gantrisin sulfadiazine erythromycin and penicillin neomycin and polymixin B. Gram stain showed a few epithelial cells and polymorphonuclear leucocytes a few gram positive cocci in pairs and rare diphtheroid bacilli.

The patient was placed on achromycin. A biopsy was attempted in the office but the patient exhibited syncope, and the procedure had to be terminated. He was hospitalized and a biopsy specimen was obtained of the left middle turbinate. The section demonstrated 'all the tissue to be inflammatory with no normal epithelium or other pre existing structures in evidence. The cells present were necrotic leukocytes. In other areas there was a necrotic fibrinous zone beneath which there was inflammatory exudate. This consisted of lymphocytes plasma cells rare neutrophiles and small blood vessels. No fungus structures were present. A few nodular foci of necrosis occurred, but this was not accompanied by cellular features of granulomas which produce tubercles'.

A diagnosis of "necrotic inflammatory tissue etiology not apparent" was made by the pathologist who commented that the biopsy specimen was not diagnostic and that changes present were not those of scleroma. They were more consistent with a necrotising inflammatory disease such as diphtheria, Vincent's angina agranulocytosis and chemical injury. Diphtheria was excluded by smear and culture.

The blood count showed a leukopenia (4 800) with a relatively normal white cell distribution. The red blood cells numbered 4 700 000 with 14.1 Gm hemoglobin, and showed no atypical morphological forms. The platelets were normal in number. The Kolmer and Kline tests were both negative,, and the tuberculin skin test was negative.

On Aug 15, 1955, the patient showed no improvement. His internist suggested administration of meticorten to rule out the possibility of a collagen vascular disease. At the same time he was continued on achromycin to lessen the purulent discharge.

tion reaction and secondary infection added to the gross deformity It would have been of interest to note how the administration of Cortisone would have affected this patient's course

Case 9 A white woman aged 25, was seen in the Ear Nose and Throat Clinic of the White Memorial Hospital on Dec 12 1952, complaining of nasal blocking, sore throat, cough and loss of taste of three months' duration There was an associated irregular fever which, at times, went up to 101° F, preceded by chills and followed by marked perspiration A recent loss of 20 pounds in weight was noted Her past and personal histories were not significant

Physical examination revealed a thin white woman with an oral temperature of 101° F, pulse 116, and respirations 24, obviously ill The nose was blocked completely on both sides by red swollen turbinates and septal mucosa Purulent material was noted in both sides of the nose, and the posterior choana were blocked by swollen posterior tips of both inferior turbinates An ulceration in the middle of the hard palate about 0 5 cm wide with redness and induration of the borders, was noted in the mouth She was admitted to the hospital with a clinical impression of "Infectious midline granuloma involving the floor of the nose the septum and the hard palate"

Laboratory tests showed 91 per cent hemoglobin, 4,870,000 erythrocytes and 2,500 leucocytes per cubic millimeter with 68 per cent neutrophiles A biopsy was made from the palatal lesion and reported as an atypical anaplastic type tumor X rays of the sinuses showed increased opacity in the right antrum Chest X-ray showed no abnormalities The urine did not show sugar or albumin Pus was obtained from the right antrum and mucopus from the left antrum Smear and culture of this material was negative for acid fast and diphtheria organisms Sensitivity tests of the isolated organisms showed them to be sensitive to several antibiotics The blood sugar was within normal limits Wassermann, Kline and Kahn tests were negative

Another biopsy (2 5x1 0x0 5 cm) was obtained, and again a report was made of anaplastic tumor It was the consensus of the otolaryngological staff that the appearance of the lesion was that of an infectious granuloma of undetermined origin, in spite of the pathological reports

The patient continued with an irregular daily elevation of temperature She was placed on streptomycin 0 5 Gm twice daily intramuscularly She was also given Vitamin C, 100 mg and synkovite 10 mg daily because of the bleeding The maxillary sinuses were irrigated daily, but pus continued to drain Because of the difference of opinion regarding the diagnosis, X ray therapy for the infection was given on three occasions Terramycin in 250 mg doses four times daily was added to the other medications with slight improvement shown She was discharged home

The nasal discharge and swelling continued, and on Jan 12, 1953 a Caldwell-Luc procedure was performed on the right maxillary sinus The sinus was explored without finding any gross infection The mucous membrane was found to be edematous but did not contain granulomata or tumor lesions A specimen of the septal swelling, removed for biopsy, was reported again as anaplastic carcinoma with a great deal of inflammatory reaction Specimens from the hard palate maxillary sinus mucosa and turbinates were all reported as being benign She felt improved after the surgery and was discharged from the hospital

There followed several other hospital admissions because of frequent the floor. The impression at the time of examination was that it was more of a granulomatous process rather than neoplastic. X-rays of the sinuses showed thickening of the maxillary sinus mucosa and a smooth polyp on the floor of the right antrum. A smear for scleroma and fungus was taken and later proved negative for both.

The biopsy specimen of the mass was reported as epidermoid carcinoma Grade 1, although the most striking feature of the section was the marked chronic inflammatory infiltration. Another biopsy was made four days later which was interpreted as a granulomatous reaction strongly suggestive of Hodgkin's disease. A third biopsy two weeks later noted "the pattern of the cells is that of a neoplastic process and is more likely that of Hodgkin's granuloma rather than undifferentiated squamous cell cancer, although the latter cannot be ruled out."

The leucocyte count was 7,400 with 60 per cent neutrophiles, 26 per cent lymphocytes and 14 per cent monocytes. The erythrocyte count was 4,900,000. Culture from the nose showed E. coli. The organism was sensitive to most of the antibiotics except penicillin and polymixin. The Kolmer and Kahn tests were negative.

The patient was placed on streptomycin intramuscularly and achromycin orally. Wydase was instilled into the left antrum after irrigation. The consultant in charge of the case thought that the lesion appears more granulomatous rather than neoplastic even after seeing the pathological studies. He felt that it was a lethal midline granuloma and advised blood transfusions; however, only one transfusion of 500 cc. citrated blood was given before he was transferred to another hospital for X-ray therapy. The patient was given a total of 1400 r through two portals beginning Dec. 29, 1955 to Jan. 10, 1956. The swelling in the nose spread to the face and the patient showed signs of toxicity. The fever rose irregularly every day, spiking at times to 101°. Antibiotics were resumed but this did not affect the course of the disease. Necrosis and sloughing was noted over the right side of the nose over the alar cartilages. This spread across the midline to the right side and cheek.

A review of the pathological slides by a pathological consultant was made. It was his opinion that a diagnosis of epidermoid carcinoma was most consistent with the findings.

Patient was readmitted to the hospital on Jan. 22, 1956, when increasing redness of the skin, ulceration and necrosis of the nose and cheeks was noted. The nose was completely blocked by a friable, partially necrotic mass. Purulent discharge drained from the right side of the nose. The lip and eyelids were swollen. The blood cell counts showed a progressive drop in the white cells until it reached a count of 1200 on March 12, 1956, but there was no relative neutropenia. A bone marrow study showed no abnormal findings. One blood transfusion was given with a resulting slight rise in the total cell count. The fever continued septic in character with daily spiking to 102-103°, in spite of antibiotics. The whole face became edematous and subcutaneous hemorrhages obliterated the facial markings. On April 7, 1956, the ulceration extended over the forehead. The white count dropped to 1,000, there was a sustained elevated temperature, and the patient expired on April 8, 1956.

No postmortem examination was performed.

Comment. It was unfortunate that an autopsy could not be obtained to confirm the pathologist's impression of epidermoid carcinoma. The lack of response of this type of neoplasm to X-ray therapy was not unexpected. The associated radiation reaction and secondary infection added to the gross deformity It would have been of interest to note how the administration of Cortisone would have affected this patient's course

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There followed several other hospital admissions because of frequent recurrences At one time a left antrum window was done At another hospital admission because of increase in the swelling and pain, she was given Cortisone, 25 mg four times daily, penicillin 300,000 units daily, streptomycin 0 5 Gm, and aureomycin 250 mg four times daily The temperature receded to normal, and the patient felt greatly improved

Two months later the patient was readmitted to the hospital gravely ill and with recurrence of the swelling in the nose The granulomatous swelling involved the septum, floor of the nose, and both inferior turbinates It bled easily and pus drained from both middle meatuses and antral windows The face was swollen with the greatest involvement over the upper lip, nose, cheeks and lower lids The temperature was elevated, sometimes rising to 104° F, and the patient complained of severe pain over the face and also of headaches

The blood count now showed the leucocyte count to be 2,200 per cubic millimeter with 63 per cent neutrophiles (14 band cells) Culture of the pus from the nose yielded staphylococcus albus

The patient was placed on the critical list Because of the continued leukopenia and apparent lack of resistance to infection, it was decided to administer blood to the patient Improvement was noted after the first pint of blood was given Daily transfusions of 500 cc of blood followed for three days The general improvement was marked The temperature subsided to normal and the swelling of the face receded in the next three days The blood count now showed the leucocytes 5,000 per cubic millimeter with 58 per cent neutrophiles and a few band cells present She was discharged from the hospital and continued to improve at home Two more transfusions were given in the following month with apparent acceleration of the healing in the nose and palate Four months later the nose was completely healed, and she was breathing well The leucocyte count remained at 5,200 per cubic millimeter with a normal distribution ratio

The patient has been observed regularly since, particularly for the upper respiratory infections She has had one pregnancy with delivery of a normal child since that time When last seen, now approximately five years since her grave illness, she seemed to be in excellent health

Comment This patient exhibited the typical findings and appeared to pursue the same clinical course as the so-called "lethal midline granuloma" cases Supportive therapy and alertness in detecting causative factors would seem to offer the greatest hope in these cases This case illustrates the varied causative factors that may produce lesions resembling the lethal type In this case, it was possible, fortunately, to discover and counteract the poor resistance to infection exhibited by this patient with blood transfusions One may postulate that the relentless destruction seen in some cases of lethal midline granuloma may be a manifestation of lack of resistance to even minor infections

CONCLUSIONS

This study is based upon a review of nine cases diagnosed

TABLE I

	Sex	Race	Age of Onset	Duration	Area of Involvement	Preliminary Diagnosis	Treatment	Final Diagnosis	Final Result	Last Seen
Case 1 (F N)	M	W	33	13 *mos*	Palate nasopharynx	Lethal midline granuloma	Antibiotics, Cortisone, *X ray therapy*	Lymphoepithelioma	Cured*	6 years later
Case 2 (M H)	F	W	27	10 mos	Palate, nose	Lethal midline granuloma	Antibiotics, antimony, iodides	Transitional cell carcinoma	Died—autopsy	
Case 3 (E S)	M	N	34	6 mos	Palate, floor of nose	Lethal midline granuloma	Antibiotics, *ACTH and Cortisone*	Collagen disease, type (?)	Cured	6 mos later
Case 4 (J P)	M	W	42	8 *mos*	Gums, sinuses, dura, kidneys, nose	Lethal midline granuloma	Antibiotics, ACTH, Cortisone	Wegener's granuloma	Died—autopsy	
Case 5 (G T)	M	N	72	10 mos	Soft palate, nasopharynx	Lethal midline granuloma	Antibiotics, X ray therapy, iodides	Ackermann verrucous carcinoma	Died—no autopsy	
Case 6 (S H)	M	N	62	6 *mos*	Nose	Lethal midline granuloma	*Streptomycin* injected locally	Tuberculoma of nose	Cured	2 years later
Case 7 (L H)	M	W	32	4 mos	Nose, palate, bones face	Lethal midline granuloma	Antibiotics, ACTH, blood transfusions	Osteomyelitis face bones(?), lethal midline granuloma (?)	Died—autopsy	
Case 8 (E T)	M	W	36	16 mos	Nose, face	Epidermoid carcinoma or lethal midline granuloma(?)	Antibiotics, X ray therapy, blood transfusions	Epidermoid carcinoma(?) Lethal midline granuloma(?)	Died—no autopsy	
Case 9 (B C)	F	W	25	6 mos	Palate, nose	Lethal midline granuloma(?)	Antibiotics, *blood transfusions*	Blood dyscrasia	Cured	5 years later

*NOTE "Cured" is used in the sense that the patient recovered and has not shown signs of recurrence since last seen (Apparent effective therapy italicized) recurrences At one time a left antrum window was done At another hospital admission because of increase in the swelling and pain, she was given Cortisone, 25 mg four times daily, penicillin 300,000 units daily, streptomycin 0 5 Gm, and aureomycin 250 mg four times daily The temperature receded to normal, and the patient felt greatly improved

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*NOTE "Cured" is used in the sense that the patient recovered and has not shown signs of recurrence since last seen (Apparent effective therapy italisized) as lethal midline granuloma Three of the cases were encountered in private practice, while the other six were found as a result of a survey of clinic patients at the Los Angeles County Hospital, White Memorial Hospital and Santa Fe Hospital The diagnosis of lethal midline granuloma was established in all the cases after routine clinical and laboratory studies excluded other possible causes, however, after continued observation and study it was possible, in five of the nine cases, to establish a definite diagnosis Of these, four cases survived and were returned to normal health The specific diagnoses established included neoplasm in three of the cases, tuberculoma in one case, and blood dyscrasia (leukopenia) in the other case (see Table) Only two patients were over 45 years old, and men predominated seven to two

As a result of this study, I believe that the gross clinical description known as lethal midline granuloma can be produced by a variety of mechanisms We are all familiar with similar ulcerative necrosis produced by the specific granulomata, blood dyscrasias and infections such as *osteomyelitis* and others This may be a manifestation of poor resistance to infection It can also be produced by some neoplasms which may have common histological features There is also intriguing theoretical and experimental evidence that a vascular necrotizing mechanism related to the collagen diseases may be a basis for this type of lesion

At the present time, lethal midline granuloma represents little more than a general term for a number of conditions causing tissue ulceration and destruction whose fundamental character and pathogenesis is still poorly understood With pathognomonic criteria absent, both clinically and histologically, one may question whether lethal midline granuloma can be justified as a pathological entity except as a tentative diagnostic expedient At best, it serves as a wastebasket for conditions difficult to recognize At worst, the chief danger of complacently accepting this diagnosis is that it may mask a specific disease process until it is too late for effective treatment

It is anticipated that with our increasing knowledge of tissue changes under stress phenomena, or as yet unknown mechanisms, this clinical diagnosis will be removed from the group described in terms of gross appearance and behavior and placed in a more precise etiological category

As clinicians, our aim in the management of these cases is twofold diagnostic and supportive

The persistence in diagnostic investigation of these cases, in spite of discouraging and sometimes hopeless odds, may spell the difference between success or failure Systemic and repeated attempts to rule out those conditions which may be masked by the lethal midline granuloma clinical picture is imperative

As was stated previously, it was our experience that a neoplastic process may be masked by inflammation and necrosis This is particularly true in the case of the lympho-epithelial group which is often found in this region Cortisone and antibiotics may play an added role in abolishing the inflammatory reaction, thus allowing the neoplasm to be recognized The ultimate value of Cortisone is still to be appraised in the future as more experience with this drug is gained

The lack of normal resistance mechanisms is characteristic of these patients It is generally recognized that they are usually sicker than they realize Supportive measures to help stimulate and sustain resistance is of utmost importance The longer these patients are kept alive in a relatively good state, the better the chances for ultimate recovery Proper dietary intake, measures to combat anemia and leukopenia by medication and blood transfusions should be instituted promptly when found The value of blood transfusions is well illustrated in cases where it proved life-saving

It is encouraging that the new concepts relating to tissue immunity responses, stress phenomena and the collagen diseases have opened a new door for promising investigation and offer new hope of answering many questions

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LARYNGOFISSURE IN THE TREATMENT OF LARYNGEAL CARCINOMA

A Critical Analysis of Success and Failure

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INTRODUCTION

Laryngofissure has been used for many years as a method of treatment for selected cases of laryngeal carcinoma (Howie[1], Thomson[2]) It has produced gross five-year survival rates varying from 59 to 87 per cent (Schall[3], Wang and O'Donnell[4], Marchetta, et al [5], and Jackson, et al [6]) Restated, this means that laryngofissure fails to control the cancer in from 13 per cent to 41 per cent of the cases What are the factors that account for the failure of this therapeutic modality? The purpose of this paper is to evaluate critically factors associated with success or failure of laryngofissure in the treatment of carcinoma of the larynx These data are not available in the literature to our knowledge

MATERIAL AND METHODS

All coded cases of carcinoma of the larynx treated by laryngofissure during the period 1939 to 1954 were selected from our files These are consecutively accessioned cases that represent the combined experience of a group of otolaryngologists at McMillan Hospital The clinical histories, pathological protocols, and microsections were carefully reviewed The paraffin blocks were recut whenever the available microsections were not of good quality

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Of the original 84 coded cases five were discarded because on review of the tissue sections no evidence of carcinoma was seen. Four of these five patients are alive for more than five years. The remaining patient died of heart failure three years after laryngofissure. Thus, a group of 79 cases with authenticated epidermoid carcinoma of the larynx were left for study. The age and sex distributions are shown in Table I. The difference between the median ages for males and females, 60 and 49 years respectively, is statistically significant, ($X^2 = 5.7$ $P < .02$).

Our criteria for the evaluation of laryngofissure as a method for treating intrinsic* epidermoid carcinoma of the larynx are as follows:

TABLE I

Age Distribution by Decades of 79 Patients Treated by Laryngofissure

	IV	V	VI	VII	VIII
Male	2	7	28	24	9
Female	3	1	3	2	0

The operation is considered a success if

1. Laryngofissure was the only definitive therapeutic procedure.
2. The patient is alive five years or more without evidence of persistent carcinoma.
3. The patient died in less than five years, was necropsied and no persistent carcinoma found. (We would exclude those patients dying in the immediate postoperative period.)
4. The patient died five years or more after treatment without evidence of persistent carcinoma.

It is considered a failure if

1. Subsequent irradiation therapy or surgery were employed.

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*The term intrinsic is used to define a carcinoma limited to a mobile true vocal cord that does not involve the anterior commissure or the subglottic area.

2 Persistent carcinoma was demonstrated by biopsy

3 The patient died of carcinoma of the larynx

4 The patient died in less than five years without being necropsied

5 The patient was lost to follow-up

RESULTS

In this study 45 cases, 57 per cent, satisfy the criteria for success *Thirty-nine* of these patients are surviving from five to 18 years, *three* died of other causes five, eight, and 16 years respectively after fissure, *three* died one, one-and-one-half and seven years, respectively after fissure, and at autopsy no residual carcinoma was found

Thirty-four cases, 43 per cent are classified as failures *Ten* of these are surviving five or more years after laryngofissure without evidence of tumor, six of the ten survivors had subsequent laryngectomies, three irradiation therapy and one both irradiation therapy and laryngectomy, *one* patient died six years after fissure and irradiation therapy without clinical evidence of tumor, *twelve* individuals died of carcinoma of the larynx Six of these twelve received further therapy, either surgical, radiotherapeutic, or both, these deaths occurred from less than one year to eleven years after fissure* *Seven* patients died in less than five years without autopsy, three patients were lost to follow-up, one of the patients presently lost to follow-up is known to have had biopsy proven persistent tumor in the neck five months after fissure

When the series is divided into two groups, the cases from 1939 to 1947 (Group A), and from 1948 to 1954 (Group B), 33 and 46 patients are in the groups respectively (see Table II) Applying the above criteria, figures of 39 per cent for success and 61 per cent for failure are derived for Group A,

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*Two patients who died of carcinoma lived for four and six years respectively after fissure without clinical evidence of cancer they then presented with carcinoma involving a contiguous portion of the larynx and died eleven and eight years after fissure It is possible that these are cases of secondary primary tumors We can not prove this and therefore they are classified as above

70 per cent for success and 30 per cent for failure in Group B. In Group A, 27 per cent (9/33) of the patients treated eventually died of laryngeal cancer, whereas in Group B only 7 per cent (3/46) of the patients died of cancer. The salvage of patients with incompletely excised or persistent carcinoma increased from 9 per cent (3/33) in Group A, to 20 per cent (9/46) in Group B. It is important to realize that these salvaged cases do not fulfill our criteria for success.

In an attempt to evaluate the objective findings associated with success or failure of laryngofissure the clinical descriptions of the laryngeal lesion and pathological data were reviewed. Unfortunately, the clinical descriptions were inadequate for detailed tabulation and analysis. The analysis and statistical significance of the pathological data are shown in Table III.* The differentiation of the carcinoma, invasion of the intrinsic muscle, and extension of tumor to a margin of excision are all significant observations when correlated with outcome, these factors are elaborated upon in the discussion.

TABLE II

Results of Laryngofissure 1939 to 1954*

	Group A (33 patients) 1939-1947	Group B (46 patients) 1948-1954	Total (79 patients) 1939-1954
1 Alive > 5 years without further treatment	33	61	49
2 Died < 5 years with autopsy	0	7	4
3 Died > 5 years without further treatment	6	2	4
4 Alive > 5 years with further treatment	10	16	13
5 Died < 5 years without autopsy	12	7	10
6 Died of cancer	27	7	15
7 Lost to follow up	12	0	5
Success 1, 2, 3	39	70	57
Failure 4 5 6 7	61	30	43
Success 1, 2, 3, 4	49	86	70
Failure 5 and 6	39	14	25
Indeterminate 7	12	0	5

*All figures are simple percentages rounded to the nearest whole number

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*The seven patients who died in less than five years without autopsy or clinical evidence of cancer are considered indeterminate for these comparisons and deleted prior to the calculations.

Extension of carcinoma *in situ* to a margin of excision is not significant.

The nine women represent 11 per cent of the series, approximately the same incidence reported in other series. Six are alive and well without tumor from seven to 18 years after fissure, one died seven years after fissure, and at autopsy no tumor was found, one is alive 11 years after fissure, having had a laryngectomy, and one died of cancer three years after fissure and irradiation therapy.

TABLE III

Correlation of Pathological Findings and Outcome

	Outcome (Number of cases)					
Differentiation	Success*	Failure*	Total	Per Cent Favorable	X^2	P
Pathologic Findings						
Well	31	11	42	74	4.87	<0.05
Moderate and Poor	8	15	23	35	12.1	<0.01
In situ carcinoma, only	6	1	7	86	1.1	>0.2
Tumor at the margin	5	16	21	24	20.0	<0.01
Muscle invasion	9	12	21	43	5.4	0.02

*As defined in the text

Seven cases of carcinoma *in situ* (intraepithelial carcinoma) are included in this study. We define this lesion as one in which the entire thickness of the epithelium is carcinomatous and submucosal invasion absent. Four patients are alive and well from six to 11 years without evidence of carcinoma, one died one-and-one-half years after fissure, and at autopsy no tumor was found, two died of laryngeal carcinoma at five months and nine years, respectively.

DISCUSSION

The evaluation of a mode of therapy in the treatment of cancer is dependent upon many factors, among them being the selection of cases, skill in the execution of therapy, thoroughness and accuracy of pathological evaluation and valid analysis of the end result. The lack of these leads to misconceptions, often perpetuated, that are detrimental to and, in fact, at times fatal for patients. If the results of laryngofissure for our original 84 patients are accepted at their face value, i e, without review of the pathological findings, failures as only those dead of carcinoma and discarding the patients lost to follow-up, the five year success-rate would be 86 per cent for the entire series! By eliminating the five cases that are not histologically acceptable to us, and applying the criteria for success and failure listed previously, we arrive at the success rate reported (see Table II)

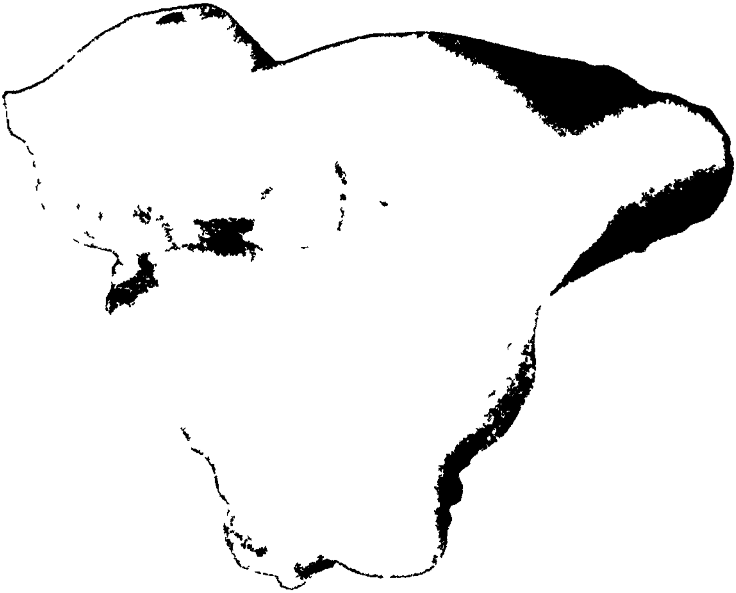

Fig 1 Laryngofissure specimen in a single block encompassing a well differentiated carcinoma of the vocal cord (Enlarged approximately two times) W U Neg No 58-5080

The ideal laryngofissure will include *in a single block*, the true and false cords, the ventricle, the vocal process and a small area of the subglottis (see Fig 1) Refinements in operative technique have led to the inclusion of the entire anterior commissure and a portion of the anterior third of the opposite true vocal cord Knowing this, and being cognizant of the lymphatic drainage of the vocal cord, automatically defines the limits of carcinomas suitable for treatment

Extension of carcinoma *in situ* to a margin of excision is not significant.

The nine women represent 11 per cent of the series, approximately the same incidence reported in other series. Six are alive and well without tumor from seven to 18 years after fissure, one died seven years after fissure, and at autopsy no tumor was found, one is alive 11 years after fissure, having had a laryngectomy, and one died of cancer three years after fissure and irradiation therapy.

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It will be noticed that five cases with "tumor at the margin" in Table III are successes for laryngofissure In addition, two cases classified as failures had "no tumor" in the fissure These contradictory findings are explicable The methods of sampling the fissure specimen for histologic evaluation varied during the period studied Until recent years they may be criticized for having been not only haphazard but also incomplete These are the faults of the pathologist In some instances they have led to laryngectomy in which no tumor was found The laryngologic surgeon who employs laryngofissure must realize the importance of removing the specimen as a single block, orienting it with care and conferring with the pathologist The entire specimen should then be step-blocked and sectioned If tumor approaches any margin, that block should be sub-serially sectioned In this manner, as is currently in use in our laboratory, accurate statements may be made and further therapy, if necessary, based on the best information The lack of such cooperation and exacting examination probably accounts for the paradoxes in Table III

Twenty-one cases had tumor at a margin of excision Of these 12 had no further therapy, and nine had either laryngectomy or irradiation therapy Of the 12 having no further therapy, five are alive and well, five died of cancer and two died in less than five years of other causes without clinical evidence of cancer Of the nine who had further therapy, five are alive and well, two died of cancer, one died in less than five years without evidence of cancer, and one is lost to follow-up Statistical analysis of these data show no significant difference between the "treated" and "not treated" groups Thus, from the review of these cases we are unable to give an objective answer to the question a surgeon might ask, "What do I do when there is tumor at a margin?" It is our opinion, however, that after the type of pathological exby laryngofissure It is not uncommon for a carcinoma to be more extensive when examined histologically than is clinically appreciated The number of patients with marginal involvement by carcinoma in our series, and the high degree of correlation of this finding with failure, is indicative that these patients were either improperly selected or that the fissure was inadequate—if the cancer was actually limited to the area ideally encompassed by a laryngofissure

Invasion of the intrinsic muscle gives a most pessimistic bias as to outcome Only 24 per cent of patients with this finding were treated successfully in this series (see Table III) This finding is usually, though not always, heralded by impaired mobility of the true vocal cord Again, the acumen of the laryngologist is taxed, and though some cases with muscle invasion are successfully handled by laryngofissure, careful consideration of the high chance of failure should be given before this method of therapy is employed

The differentiation of the carcinoma must also be considered Well differentiated cancers are treated successfully in 74 per cent of such cases in our series Moderately and poorly differentiated cancers, however, are controlled by laryngofissure in only 35 per cent of such cases in our series The designation of the differentiation of these carcinomas is a factor dependent upon the pathologist He must examine the biopsies with care and cognizance of what his diagnosis will mean

The functional result of the larynx that has been treated by laryngofissure must be considered in the evaluation of the procedure The patient can breathe through his larynx in the majority of instances, however, the incidence of postoperative "granulomas", stricture and membrane formation is not negligible (LeJeune and Lynch[7]) and does necessitate further surgical intervention Two patients in this series have permanent tracheotomies because of laryngeal stenosis Interference with swallowing is rare Post laryngofissure patients do have a voice, but one that is hoarse In effect, the functional result in relation to voice is something less than desirable It is a fact that carcinomas of the vocal

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SCHOLARSHIPS FOR NASAL SURGERY COURSE

The American Rhinologic Society provided full scholarships to five Mexican physicians, and half scholarships to six, to enable them to attend a course in reconstructive nasal surgery presented at the White Memorial Hospital, Los Angeles, January 9-16, 1959

Dr Amos E Friend of Manchester, Conn, chairman of the Society's Public Relations Committee, said the scholarships were designed to further cement international relations as well as to spread surgical knowledge amination we advocate when tumor is at a margin of excision, irradiation therapy should be used rather than resorting to laryngectomy

CONCLUSIONS

1 A review of the clinical and pathological data from 79 patients having had laryngofissure for carcinoma of the true cord reveals an overall success rate for the procedure as 57 per cent

2 The degree of differentiation of the carcinoma, the presence of tumor at the excisional margins, and invasion of the intrinsic muscle are pathological features that are significantly related to the failure of this technique

3 Sucess of laryngofissure is dependent upon careful selection of candidates for the procedure, *en bloc* removal of the specimen so as to encompass the lesion, and careful pathological examination and interpretation

4 From analysis of the data no meaningful statement regarding future therapy in those cases with "tumor at the margin" can be made

5 Periodic follow-up examinations of post-laryngofissure patients should never cease because of the late appearance of persistent tumor and possible second carcinomas

6 Because the survival rates of patients with intrinsic laryngeal carcinoma treated by irradiation are as good as, if not better, than those treated by laryngofissure, and because the functional result in terms of voice is better after irradiation therapy, it would seem that irradiation should supplant laryngofissure as the therapy of choice

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of the rubella virus as a cause of congenital defects including deafness, and by Goodhill, of the significance of the Rh factor as a cause of nuclear deafness Goodhill has stated, "The recent discovery that rubella (German measles) in the mother during the first trimester of pregnancy might ~~cause~~ deafness in the child was the first major contribution to the etiologic analysis of infantile nerve deafness in the present century" Goodhill's work represents another such contribution

Congenital Deafness

Kinney, Goodhill, Fowler and Van Egmond have emphasized the ambiguity of the term "congenital," and the tendency in recent otological literature has been to discard it Formerly the term *congenital* has often been used as equivalent to hereditary Van Egmond points out the following three possibilities

1 Deafness may be congenital but not hereditary, as in deafness caused by rubella during pregnancy

2 Deafness may be hereditary but not congenital, as in otosclerosis

3 Deafness may be congenital and hereditary as in sporadic recessive deafness

Goodhill has classified infantile deafness into

1 *Hereditary* (gene transmitted)

2 *Acquired*—

A Prenatal (infections, acquired developmental anomalies, drug intoxications)

B Natal (birth injuries and erythroblastosis fetalis)

C Postnatal (meningitis, viral acoustic neuritis, encephalitis and miscellaneous)

Fowler has classified the "congenital" causes of deafness as

1 Causes during preconception

2 Causes during pregnancy

THE PRESCHOOL NERVE-DEAF CHILD

Study of Etiological Factors*

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The purpose of this thesis is to present the results of a study of 328 children with severe hearing loss, examined by the author during the years 1949 to 1952, at the Clinic for the Deaf Child of the Winthrop Foundation for the Study of Deafness at the Massachusetts Eye and Ear Infirmary The aim of the study was to determine the causes of deafness of these preschool deaf children The pertinent available literature will be reviewed

The Clinic for the Deaf Child of the Winthrop Foundation was established through the foresight of Drs LeRoy A Schall and Harold D Walker in 1940 The purposes, scope, organization and accomplishments of this clinical research program have been reported by Guilder, Guilder and Schall, Meltzer and Lewis The author is grateful to Drs Schall and Meltzer for the opportunity given him in 1949 to direct the Clinic for the Deaf Child for several years, and thus to be intimately associated with an inspiring group of youngsters and their parents, and a devoted group of co-workers

REVIEW OF THE LITERATURE

Etiological Factors

In recent years there has been a great increase in interest in the preschool child handicapped by deafness, and numerous excellent papers and books have been written on the subject Our concepts as to the etiology of deafness present at birth (previously often loosely labeled as "hereditary" or "congenital") or acquired in early life are changing, especially since the monumental discovery by Gregg of the significance

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per cent of the children was labeled congenital, and in 11 per cent of these "congenital" cases it was labeled hereditary Carruthers (1945) cites Fraser, who in 1922 analyzed the histories of 135 deaf mutes at the Edinburgh Royal Institution for Education of the Deaf and Dumb Of these, 75 were classified as congenital deaf mutes and 60 as cases of deaf-mutism acquired in early life In only 21 of the congenital deaf mutes was there any possibility of a hereditary factor That left 51 cases in which some extraneous cause was responsible These figures agreed with the quoted figures of numerous other investigators quoted by Fraser that slightly over 50 per cent of cases of deaf-mutism are congenital and about 30 per cent of these are hereditary (or about 15 per cent of the total)

On the other hand, Bordley (1952) reported an analysis of etiologic factors underlying impaired hearing in 485 preschool deaf children He found familial deafness in only 18 of these children (less than 4 per cent) Fowler reported 81 children with prenatal causes of deafness out of 270 deaf young children Of the 81, only 10 were ascribed to "causes during preconception," (seven hereditary deafness, one with retinitis pigmentosa, and two with syphilis), an incidence of 3 7 per cent of the total (10/270)

Kerr Love wrote in 1921 "The thing most wanted from the pathologist at present is a series of postmortem examinations of undoubtedly deaf-born children" Carruthers adds that "This is still true in 1944" Kinney reported in 1950 that following a complete survey of all published volumes of the *Cumulative Index Medicus* he found 42 articles on the subject of hereditary deafness, however, he was unable to find a single human case in which there was an accurate history and acceptable hearing tests combined with pathological study of both the temporal bone and brain "There is not one American case This is a very shocking condition, and I would urge that effort be put forth to obtain such specimens from cases that might be within our knowledge" He suggests that a central repository of such case histories and specimens be established by the American Otological Society

Altmann (1950) made a very scholarly, comprehensive re-

3 Causes during labor

1 *Hereditary Deafness*

According to Van Egmond there are two types of hereditary deafness, namely *dominant inner ear deafness* and *recessive sporadic deafness*

a Dominant inner ear deafness usually develops at middle age and is progressive, it is rarely congenital, however, he cites the work of Waardenberg, who in 1951 described a hitherto unknown hereditary syndrome of six chief characters, one of which was congenital dominant deafness (present in 20 per cent of the cases)

b Recessive sporadic deafness is the common form of inherited deafness in man Because the gene for deafness is transmitted as a recessive characteristic, consanguinous marriages have a profound effect on its incidence This fact was noted by Fay in 1889, long before the laws of inheritance were known Ballenger reports that 47 marriages between blood relations produced 72 deaf mutes Hopkins et al, made an extensive study of 310 pedigrees at the Clarke School for the Deaf They found that the incidence of cousin marriages among the families of the deaf children was about 8 per cent as compared to 0 2 per cent in the general population The excellent and detailed reports on heredity and consanguinity by Shambaugh and Yearsley are worthy of study

The incidence of hereditary deafness is difficult to ascertain from the literature, as the percentages vary greatly, and undoubtedly numerous cases of acquired deafness have been erroneously labeled hereditary in past statistical reports

Thus, Van Egmond states that "the number of cases of congenital deafness by heredity is presumably half to one third of all the deaf, recessive deafness strongly predominating According to Dahlberg two-thirds of the congenital deaf would be deaf by heredity" Beasley, reporting the results of a survey of the schools for the deaf by the United States Public Health Service, states that the deafness in 61 which cardiac lesions and deafness were reported as important sequellae Among these were the reports of Swan et al Carruthers, Welch, Martin, Evans, Murray and Hiller

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*See also the interesting paper by Alexander Graham Bell (1883)—Memoir Upon the Formation of a Deaf Variety of the Human Race' Reference No 156

Gregg (1946) reported an incidence of 111 cases of deafness, 38 with heart disease, and 23 with eye defects in 130 cases of rubella Swan et al, (1946) gave a detailed analysis of the sequellae of maternal rubella These included cataracts, deaf-mutism, heart disease, microcephaly, umbilical hernia, bifid uvula, mental deficiency, speech defects and strabismus

Murray (1949) made a thorough study of 105 rubella-deaf children He found no difference in the degrees of deafness when the rubella was contracted at six weeks and at three months Most of these children were only moderately to severely deaf but not totally deaf, with an average loss over the speech range of 65 db in the better ear They can be benefited by the use of hearing aids He, therefore, deplores the use of the term "deaf-mute" for these children In the same year, Hiller studied 42 congenitally deaf children Of these, 32 were of rubella origin, and had audiometric findings similar to those reported by Murray.

In 1946 Martin reported 36 cases of deafness due to maternal rubella out of 102 deaf children studied The rubella was presumably contracted during an epidemic in Britain in 1940 and 1941

Among American authors, Goodhill (1950) notes the following Reese, Erickson, Altmann and Dingman, Hopkins, Ober et al, Aycock and Ingalls, Fowler, and MacFarlan

Ober, Horton and Feemster reported (1947), 17 abnormal pregnancies in a study of 54 mothers who had rubella in 1943 in Massachusetts Of the 17, abortions occurred in nine, and the other eight produced infants with abnormalities

Aycock and Ingalls emphasize the seriousness of maternal rubella as a cause of disease in infants They suggest the possibility that other virus diseases, including poliomyelitis, may be the cause of many fetal diseases and developmental anomalies

MacFarlan (1948) emphasized that "recent investigations view of the otolaryngological literature on the histologic picture of inherited nerve deafness in man and animals, and he reports two cases of his own This work is a classic and will certainly facilitate research in the future He concludes that “the anatomic findings in inherited deafness can be divided into two types

1 Primary changes in the cochlear duct and saccule *a* changes confined to the epithelial parts of the cochlear duct with or without involvement of the saccule (so-called sporadic deaf-mutism in man, deafness in dogs and cats with pigment anomalies, deafness associated with locomotor anomalies in rodents) , *b* additional slight anomalies of the osseous framework of the cochlea (in man) , and *c* marked anomalies in the membranous and osseous parts of the cochlea, the saccule, the endolymphatic duct and sac (so-called typus Mondini in man and dogs) In all the subgroups, particularly the last-named one, coordinated anomalies of the central cochlear system might be present

“*2* Primary degenerative atrophy of the spiral ganglion on the basis of an inherited ‘localized weakness of the cochlear system (man, horses) ”

2 *Acquired Deafness*—

A Prenatal Causes—*1* Maternal rubella

In 1941 Gregg, an ophthalmic surgeon in Sydney, New South Wales, reported a marked increase in the number of cases of congenital cataract and heart lesions in children of mothers who had rubella during the first trimester of pregnancy This followed a pandemic outbreak of rubella in Australia in 1939 and 1940 He suggested that rubella contracted by mothers during the first trimester was the direct cause of congenital cataract and other defects As Wilson points out, he was deservedly honored with a knighthood for his monumental discovery

Goodhill, in an excellent study of the nerve deaf child has reviewed the history of rubella observations by Australian, British and American authors Following Gregg’s published report, a number of articles appeared from Australia in et al (1953), and Lindsay and Harrison (1954) and Wilson (1955)

Rubella, and possibly other infectious or toxic agents, attacks that part of the embryo which is most actively developing at the time of infection "It is recognized that above all, the timing of the interference is the vital factor The same type abnormality is producible by several methods experimentally providing they are applied at the same developmental stage, and it thus appears that for each part of the body there is a time, its critical developmental period, at which it would be selectively affected by any one of many methods though in varied degree" (Lindsay) Swan (1949) found that the average period of pregnancy for congenital cataract was 1 4 months, for heart lesions 1 5 months, and for deafness 2 3 months Murray (1949) points out that the inner ear appears to be most easily damaged between the sixth and twelfth week

Lindsay and Harrison (1954) state that though the amount of pathological material is small, a comprehensive picture of the histo-pathology of this condition has emerged They find that rubella in the first trimester produces in the child the sacculo-cochlear (Scheibe) type of malformation of the inner ear similar to the hereditary type, with the greatest defects noted in the apical coils The bony labyrinthine capsule is always normal, as are the cells of the spiral ganglion and the nerve fibers, utricle and semicircular canals

B Natal Causes—1 Erythroblastosis Fetalis

The establishment of a definite relationship of kernicterus and erythroblastosis with bilateral nuclear deafness by Goodhill in 1949 was a great advance in the search for the etiological factors of nerve deafness in early childhood

In 1875 Orth first noted the relationship of severe jaundice in new-born infants with the postmortem yellow pigmentation of certain nuclear masses of the brain To this pathological staining Schmorl applied the term "Kernicterus" in 1903

Zimmerman and Yannet, in 1933, pointed out that "jaunshow that rubella in the pregnant mother is a frequent cause (of deafness) even though the attack may be mild"

Lemmon (1950) stated that if a woman contracts rubella during the first 100 days of pregnancy, the chances are one in four the offspring will have some severe congenital defect Landtman (1948) felt that other diseases, including the common cold, influenza, and pneumonia, may have a similar effect

The percentage of cases of deafness in infancy caused by rubella is variable This may be due to the fact, stressed by Goodhill, that the earlier reports emphasized the cardiac and ocular lesions and were made while the children were still too young for careful audiological evaluation The later statistics "show clearly that deafness was by far the most common sequel of maternal rubella, and that congenital cataract and congenital cardiac disease were relatively infrequent sequellae"

As noted above, Martin reported an incidence of 35 per cent in his study of 102 deaf children in Britain Of 147 cases with congenital lesions, Carruthers (1945) found 80 per cent (116) were severely deaf Of 102 cases with a definite history of maternal rubella, 74 were deaf and 14 have congenital heart lesions

Goodhill (1950) found that of 904 deaf children studied, maternal rubella in the first trimester of pregnancy was the potential cause of deafness in 186 (20 5 per cent), as against 3 per cent caused by erythroblastosis and 10 per cent caused by meningitis

In Bordley's report (1952), maternal rubella is shown to be the cause in 24 out of 485 cases (5 per cent), as against 29 cases caused by erythroblastosis and 49 cases due to meningitis Fowler and Basek (1954) report 12 cases of maternal rubella out of 270 cases (4 5 per cent, as against 12 cases due to the Rh factor, and 10 cases due to meningitis

The pathology in the temporal bones in rubella deafness has been discussed by Carruthers (1945), Swan (1949), Schall, Lurie and Kelemen (1951), Nager (1952), Lindsay of our knowledge, deafness has never been described as one of its sequellae," being apparently unaware of the above-mentioned reports

In 1950 Evans and Polani reported on 16 patients with neurological sequellae of erythroblastosis, of which five are deaf (30 per cent) Crabtree and Gerrard (1950) reported 16 cases of perceptive deafness in 20 cases of kernicterus (80 per cent) Pearlstein (1950) reported that deafness is a common sequel of kernicterus, occurring in 40 per cent of cases

In 1952 Johnson found among 50 cases of nerve deafness six cases probably due to Rh incompatibility In the same year Gerrard wrote an excellent summary of kernicterus and pointed out the frequency of deafness as a sequel Bordley (1952) reports erythroblastosis as a causative factor in 29 out of 485 cases of preschool deaf children (6 per cent)

Kinney (1953) reports 14 cases out of 630 children with partial perception deafness (2 2 per cent) caused by erythroblastosis Fowler and Basek (1954) found an incidence of 12 cases due to the Rh factor out of 270 cases (4 5 per cent) Cavanagh (1954) published an excellent review of "The Rhesus Factor in Deafness" She found three cases of Rhesus sensitization among 118 deaf children Among 124 Rhesus babies she found six cases of deafness, "none of which had been suspected, although most of the children had been well cared for domestically and medically" She concludes that it "would seem, therefore, that the attention of otologists and pediatricians ought to be drawn to this possible sequel of Rhesus incompatibility If every Rh negative woman is delivered where there are facilities for testing the cord blood and for an early exchange transfusion (repeated as necessary), then Rhesus children should cease to be crippled by kernicterus or deafness"

The neurological lesions of erythroblastosis fetalis in relation to nuclear deafness were described by Dublin in 1951 (see also his report of 1949) He examined the brains of seven newborn infants having erythroblastosis fetalis, particular attention being given to the auditory pathways He dice of the nuclear masses of the brain is most frequently, if not exclusively, associated with icterus gravis neonatorum"

In 1940, Laudsteiner and Wiener discovered the Rhesus factor in human red cells This was a new agglutinogen (protein) on the surface of human red cells (also present in the Rhesus monkey, hence "Rh") found in 85 per cent of the white population, and inherited according to Mendelian law as a dominant characteristic

In 1941, Levine, Katzin and Burnham pointed out that incompatibility between the Rh antibodies in the mother's serum and the Rh factor in the red blood cells of the newborn infant was the cause of the mysterious, and often fatal, group of diseases known as "erythroblastosis fetalis" (including "hydrops fetalis," icterus gravis neonatorum, and congenital hemolytic anemia) Lucid summaries of the relationship between erythroblastosis and the Rh factor can be found in the excellent articles by Diamond, Goodhill, and Cavanagh

In 1944 the first case of severe deafness following kernicterus was reported by Coquet In 1948 Landy reported four cases of deafness among eight cases of kernicterus

In 1950 appeared two articles by Goodhill He pointed out that "one of the sequellae of Rh factor incompatibility namely, erythroblastosis with kernicterus, may result in a bilateral perceptive deafness and other physical defects, the most common of which is athetoid spasticity" He found that of 904 deaf children studied, erythroblastosis was the potential cause of deafness in 3 per cent of the cases, as against 20 5 caused by maternal rubella and 10 3 per cent by meningitis He concludes that "the Rh factor thus takes its place in the etiologic classification of infantile preceptive deafness This position is not a major one It does not approach maternal rubella, meningitis and the exanthemata in numerical importance It is nevertheless, a significant cause and one which may point to other serologic factors in the etiology of infantile deafness"

In 1950 Barnett and Ryder published a report of one case which recovered from erythroblastotic kernicterus but had as one of its sequellae total deafness They state "to the best and principally the *dorsal* cochlear nucleus, which is the only part of the auditory pathway in which the fibers which carry high frequency impulses are concentrated (He cites the interesting papers of Lewy and Kobrak, Gasser, Lorente de No, and others to prove his point) Hereditary deafness (in contrast to the other two types) is associated with the "residual" type of audiogram (hearing only for loud low frequencies), because the organ of Corti is underdeveloped along the whole basilar membrane "The 'residual graphs' represent those cases in which total deafness would exist as a result of severe lesions in the organ of Corti, but the vibratory, quasitactile component of hearing is preserved" (Bocca, 1952 and 1953) In 2000 cases studied he found "no cases with no remnants of hearing"

2 Causes During Labor and Birth

That difficulties associated with the process of birth may be related to central nervous system damage and auditory disorders in young children has been pointed out by many authors, notably Myklebust, Windle, Doll, Moloy, and Strauss Most of these studies do not analyze specifically the problem of nerve deafness, and much research in this specific field is needed As Myklebust has stated "A number of children with peripheral hearing impairment have no other etiology except that of presumed damage at birth It is conceivable that research will reveal that birth damage can affect the blood supply to the inner ear, causing either deprivation or hemorrhage with resultant deterioration of the organ of Corti or other cochlear and auditory nerve functioning" Fisch has pointed out that the cochlear nuclei are possibly the most complicated and anoxia-sensitive basal nuclei of the brain

Windle has demonstrated the major role played by anoxia in the causation of neurological disorders in the offspring He points out that even brief periods of anoxia can produce profound and permanent changes, and he reminds us that Little, in 1862, drew attention to cerebral pathology in human infants as due to "abnormal parturition, difficult labors, premature birth, and asphyxia" found cell injury in both the dorsal and ventral cochlear nuclei, the superior olivary nuclei, the medial geniculate body, the nuclei of the inferior quadrigeminal body There were mild changes in the auditory cortex, but the cochlear nerves showed very little change The auditory pathway, therefore, is widely and symmetrically involved He stated that "the mechanism of cerebral injury in erythroblastosis fetalis is one of *anoxia* The distribution of lesions is the same as that of any anoxic disorder, such as carbon monoxide poisoning The cerebral anoxia of erythroblastosis results from the intravascular hemolysis, which deprives the capillaries, and the tissues they supply, of oxygen"

Kelemen (1956) points out that Gerrard (1952) was the first to submit the histopathological findings in the cochlea in his two cases of kernicterus which died during the neonatal period, and that no other such reports are available He reports the third case of a three-day-old infant who died of erythroblastosis fetalis and describes the findings in the hearing organs, "displacement of the walls of the membranous labyrinth, symmetrically on both sides, was represented by dilatation of the vestibular scala, slight distension of the perilymphatic cisterna, and considerable dilatation of the endolymphatic sac with edematous rugae"

In connection with the three etiological factors thus far reviewed (heredity, rubella, and erythroblastosis) the fascinating article of Fisch (1955) "The Aetiology of Congenital Deafness and Audiometric Patterns," should be noted He studied 250 cases of congenital deafness with reliable audiograms, and evaluated the pattern of audiogram as related to possible cause Thus in deafness from maternal rubella, where the lesion is in the cochlea (developmental arrest of the organ of Corti as a whole), there is a flat audiogram On the other hand, the most significant feature of deafness due to pathological conditions which complicate the circumstances of birth or immediate postnatal period (erythroblastosis, neonatal jaundice, anoxia) is "the selective loss of hearing for high frequencies" and a *sloping curve* with only moderate impairment of hearing (nuclear type of deafness) In these conditions the lesion is in the cochlear nuclei, demonstrated the transmission of streptomycin from the maternal to the fetal circulation

Kinney listed four cases of deafness due to quinine given to the mother early in pregnancy, and Fowler reports one case due to overuse of drugs

Almost 20 years ago Taylor emphasized that "if the otologist, in obtaining a history of each child showing a nerve deafness, will inquire carefully into the history of drugs administered to the mother during her term of pregnancy, the etiology of a number of perplexing and otherwise unexplained cases of nerve deafness may be solved"

b Miscellaneous Intra-Uterine Causes

1 That *virus diseases* (other than maternal rubella) and *serological incompatibilities* (other than Rh) may be etiological factors in deafness present at birth has been pointed out by authors already cited (Taylor, Aycock et al, Goodhill, Van Egmond)

2 Bordley (1952) emphasized that *maternal immunization* during pregnancy may cause deafness He reported four cases attributed to the administration of immune globulin to mothers during the first trimester of pregnancy as prophylaxis against measles He suggested that "some of the present work being done on prenatal immunization in some obstetrical and pediatric clinics should be assessed with the greatest care"

3 Congenital syphilis is no longer the significant cause of deafness it was formerly Yearsley (1934) reported 187 cases in 4,314 deaf children in England (4 3 per cent), and Shambaugh (1928) reported 24 cases out of 1,192 in the United States (2 per cent) Ballenger (1947) indicated that the incidence of congenital syphilis among deaf-mutes has been variously estimated at from 3 5 to 25 per cent In recent reports Bordley and Kinney list no cases of congenital syphilis and Fowler lists two cases (with interstitial keratitis)

4 Diabetes and *Cretinism* have been implicated as prenatal causes of infantile deafness (Kelemen, Taylor, Yearsley, Hurwitz and Skipper) Kelemen (1955) submits the first

Myklebust indicates that central nervous system damage and auditory disorders at the time of birth have been related to prematurity, post-term delivery, prolonged labor, difficult labor, Caeserean delivery, breech and other atypical fetal presentations, the use of anesthetic drugs during labor and delivery, and especially asphyxia neonatorum.

In recent clinical reports on the etiology of infantile nerve deafness, Bordley ascribes 13 cases (out of 485) to birth injuries and five to toxemia of pregnancy, Fowler reports 21 cases due to causes during labor and four due to eclampsia in his series of 270 cases, and Kinney reports 24 cases (out of 630) as due to birth injuries.

3. *Other Prenatal and Natal Causes*—*a.* Ototoxic drugs

The danger of transmission of ototoxic drugs from mother to fetus has been stressed by numerous authors. In 1848, Parak reported finding high concentrations of sodium salicylate in the urine of infants for several days, in cases in which this drug had been given to mothers 30 minutes before delivery.

Nicloux (1909) gave alcohol in milk to mothers one hour before delivery and found alcohol in the umbilical cord of the newborn in the same concentration as in the maternal blood. In 1913 Wade reported five cases of deaf-mutism attributed to chronic alcoholism in the mother. Taylor states that Pelley (1912) found "that the newborn baby of a mother who is addicted to morphine or opium is as much an addict as the mother, for the child's blood and tissues are as fully saturated with narcotic as hers."

Mosher (1938) and Taylor (1937) demonstrated the toxic effects on the organ of Corti of the offspring of quinine given to the mother.

The ototoxicity of drugs is the subject of a recent Wherry Memorial Lecture (1954) by Lurie. He points out that the ototoxic drugs—salicylates, quinine, ascaridole, neomycin and the streptomycin group—are all products of plant cell metabolism used in the treatment of bacterial disease, and are dangerous to the function of the ear. Woltz and Wiley have middle-ear suppuration and "middle-ear catarrh" as the cause in 1,424 cases (48.5 per cent).

In recent reports Bordley (1952) lists meningitis as the cause in 43, or 9 per cent, of cases out of 485 children with impaired hearing (from all causes—hereditary, prenatal, natal and postnatal). Meningitis in this listing is the leading determined cause. Of the other childhood diseases there were 31 cases of measles (Rubeola), 37 cases of unexplained fevers, eight cases of whooping cough, six cases of chicken pox, five cases of mumps, four cases of penumonia, two cases due to scarlet fever, and one case due to poliomyelitis.

Kinney (1953) reported on a study of 2,628 cases of impaired hearing in children. Of these, 910 were classified as perception cases and included 310 with unilateral loss (no hearing in one ear, normal hearing in the other) and 630 with partial (bilateral) loss. In the unilateral cases, "meningitis" is given as the cause in 23.9 per cent, measles in 23.2 per cent, and mumps in 10.6 per cent. In the 630 "partial loss perception cases" measles is blamed in 17.3 per cent as compared to meningitis 4.8 per cent, mumps 3.5 per cent, pertussis 2.7 per cent, "polio" 1 per cent. Kinney concludes that "the measles virus as a cause of perception hearing loss in children is probably of greater import than has been reported in previous publications."

Fowler and Basek (1954) reporting on postnatal causes of deafness in 189 children, lists ten cases due to meningitis, eight cases due to mumps, 14 cases due to measles and 45 cases due to otitis media. They point out that the high incidence of otitis media as compared to meningitis (4.5 to 1) in their cases is at great variance with the recent reports of Bordley and Scott-Moncrieff that meningitis is the commonest cause of postnatal deafness, but they cannot explain this difference.

Wilson points out that while scarlet fever may cause a diffuse labyrinthitis and meningitis, the most common cause of deafness in this condition is a labyrinthitis secondary to suppurative otitis media. Lindsay and Hemenway point out that this is also true in measles, and state that with proper pathological report of the findings in the ear of a six months fetus delivered by hysterectomy of a diabetic mother

5 *Congenital atresia* of the external auditory canal may produce deafness at birth, especially if there is malformation of the middle ear (Van Egmond) Altmann has written an excellent review of the subject (1951), and Wilson (1955) devotes a chapter to the subject of congenital abnormalities in his recent textbook "Diseases of the Ear, Nose, and Throat in Children"

C *Acquired Postnatal Causes*

According to Wilson (1955) severe deafness in infants and young children is usually caused by labyrinthitis or toxic damage

In the pre-antibiotic era, meningitis (especially cerebrospinal meningitis) was the commonest cause of labyrinthitis Thus Shambaugh in 1928, in reporting the cause of acquired deafness in children in schools for the deaf, lists meningitis as the leading cause of deafness in 1,192 cases studied Meningitis accounted for 17 5 per cent as compared to scarlet fever (8 4 per cent), measles (8 2 per cent), influenza (7 1 per cent), pneumonia (4 5 per cent), pertussis (3 5 per cent), infantile paralysis (3 1 per cent), mumps (1 per cent), and suppurative otitis media and its complications (5 6 per cent) In Best's report for the same year, meningitis was the leading cause with 14 5 per cent as compared with scarlet fever (7 3 per cent), measles (5 7 per cent), pertussis (4 7 per cent), pneumonia (3 7 per cent), typhoid fever (1 9 per cent), infantile paralysis (1 9 per cent), diphtheria (1 4 per cent), influenza (9 per cent), mumps (8 per cent), disease of ear and mastoiditis (2 4 per cent)

In England, Yearsley reported in 1934 on a study of over 4,000 cases of "educational deafness" seen in 25 years Of 2,935 cases of acquired deafness, meningitis was listed as the cause of 375 (13 per cent) as compared to measles (9 per cent), scarlet fever (9 per cent), influenza (8 per cent), pneumonia (1 5 per cent), pertussis (2 per cent), diphtheria (2 per cent), mumps (0 2 per cent) Yearsley, however, lists 'injury" as a cause in 139 cases (1 7 per cent), and Shambaugh (1928) lists "skull fracture" as the cause in 2 per cent of his cases, and 'fall" as the cause in 1 per cent Trauma is also listed as a cause in the reports of Kinney, and in Fowler and Basek

Schuknecht and his associates have reported interesting clinical and experimental studies of the relationship of head injury and deafness In their most recent report (1956) they point out that "partial permanent deafness occurs in about 50 per cent of patients who incur a blow to the head severe enough to produce unconsciousness Even a mild head blow without loss of consciousness can occasionally result in deafness" They classify deafness from blows to the head into three groups *1* Longitudinal fracture of the temporal bone usually causes conduction deafness through interference with the sound-conducting apparatus There is often, in addition, a perceptive deafness for high frequencies due to trauma to the organ of Corti, *2* Transverse fracture of the temporal bone passing through the labyrinth usually causes a profound loss of auditory and vestibular function, *3* Labyrinthine concussion may cause perceptive deafness without roentgenological evidence of fracture The significant pathological changes lie in the organ of Corti, with the severest damage in the upper basal turn

THE PRESENT STUDY

The records of 328 children referred to the Clinic for the Deaf Child of the Winthrop Foundation of the Massachusetts Eye and Ear Infirmary were studied to determine the probable etiologic factors These cases include those seen at initial interview and subsequent visits to the Clinic by the author, as otologist in charge, during the years 1949 to 1952, and those first seen in prior years by other otologists of the Winthrop Foundation but re-evaluated by the author during follow-up interviews

Most of the children had a complete diagnostic study consisting of *1* A detailed history and otological examination, *2* estimate of hearing and speech capacity by a trained audiometrist, *3* estimate of intelligence by a clinical psychol-antibiotic treatment, this complication of bacterial otitis media should be a rare occurrence, therefore, since the advent of antibiotic therapy, the most frequent type of deafness caused by measles will be that due to the direct effect of the virus on the inner ear ("neuro-labyrinthitis," viral acoustic neuritis, measles meningo-encephalitis) They were able to find only three cases in the literature describing the pathology in the inner ear They summarize the findings in these cases and give a detailed report of a fourth case showing "endolymphatic labyrinthitis" with secondary nerve degeneration

That *drugs* used in the treatment of bacterial infections may cause nerve deafness has already been noted in the discussion of ototoxic drugs In recent years, studies have been carried out on streptomycin, dihydrostreptomycin, and neomycin

In 1952, Walker reported on a study of 93 cases of tuberculous otitis media (most of them in children), treated by streptomycin and dihydrostreptomycin He found 68 cases with moderate to severe deafness The deafness was often preceded by tinnitus and usually became apparent in the fifth or sixth month of therapy

Dihydrostreptomycin is more likely to cause cochlear damage than streptomycin, however, both drugs have been found to cause deafness and vestibular disturbances Lurie points out that there is definite degeneration of external hair cells and internal hair cells of the organ of Corti with secondary involvement of the ganglion cells of the cochlea There is also degeneration of the hair cells in the crista of the semicircular canals and in the macula of the utricle Neomycin affected the organ of Corti and not the vestibular apparatus Lurie warns us that these drugs must be used with caution, for some patients will "pay the price of deafness with their use"

Trauma is listed as a cause of acquired deafness by numerous authors Wilson states "Trauma is a possible cause, but fracture of the skull likely to cause complete deafness would most probably prove fatal" Yearsley (1934), in reviewing 2,935 cases of acquired "educational" deafness lists or were referred from rural communities, and the pertinent information such as details of birth, neonatal history, and studies of serology and Rh factors were not available to us.

In Table I is shown the age range of the 328 children when first referred to the Winthrop Foundation. The age factor is related to etiology in that the younger the child, when the deafness was first recognized and competent help sought, the more likelihood there was of finding alert and intelligent parents, and of obtaining pertinent etiologic data. Some of these children were born before the significant relation of maternal rubella and Rh incompatibility to deafness was generally known, and this valuable information was not obtainable from the parents or their physicians.

TABLE II

Causes of Severe Hearing Loss in the Children Studied at the Winthrop Foundation

Cause	Number	Percentage
A Hereditary (Familial)	15	4.6
B Acquired Prenatal and Natal Causes (116 or 35%)		
1 Maternal Rubella	36	11.0
2 Rh Incompatibility	23	7.0
3 Causes During Labor and Birth		
a Prematurity, Twins, Placenta Praevia, Toxemia	18	5.5
b Traumatic labor, Brain injury, Cerebral palsy	29	9.0
c Cyanosis, Icterus	3	1.0
4 Congenital Anatomical Defects	7	2.0
C Acquired Postnatal Causes (49 or 15%)		
1 Meningitis	17	5.2
2 High fevers, Pneumonia, etc.	11	3.3
3 Measles	6	2.0
4 Mumps	2	0.6
5 Pertussis	1	0.3
6 Rabies Vaccine	1	0.3
7 Skull Injuries	4	1.2
8 Middle Ear Disease	7	2.0
D Cause Undetermined	148	45.0
Total	328	100.0

Less than one-third of the children (103) were examined before the age of three, and only about half before the end of the fourth year, despite the teachings of most workers in this ogist, and 4 interviews with parents or guardians by a trained psychiatric social worker. In selected cases, the study was supplemented by examination by a child psychiatrist, pediatrician, neurologist and other consulting specialists available to us at the clinics and laboratories of the Massachusetts General Hospital. In many instances, conferences with several or all of these specialists, including teachers and speech therapists, were held to aid in a total evaluation of the child and his physical, mental, emotional, social and educational needs. Wherever possible, with the aid of a full-time secretary and the social service worker, information was obtained from family, obstetrician, pediatrician, or referring medical or social agency.

TABLE I

Age Distribution of 328 Deaf Children
(At first visit to Winthrop Foundation)

Age (Years)	0-1	1	2	3	4	5	6	7	8	9	10
Number of Children	2	16	85	60	61	49	23	20	8	3	1

The most significant information relating to the probable cause of hearing loss was obtained from a detailed history similar to that suggested by Myklebust. It included:

1. Family history of deafness, speech problems and neurological disorders in parents, siblings, and other blood relations.
2. Prenatal, natal, and neonatal history.
3. History of illnesses, injuries, and inoculations since birth.
4. Neuromuscular, genetic development of the child.
5. Hearing and language development of the child, and
6. Educational history to date.

As will be noted, however, in Table II, we were unable to obtain sufficient data from the information available to determine with any certainty the probable cause of deafness in 148 of these children (45 per cent). This may be explained in part by the fact that some of our children were adopted, ous authors (Ewing, Doll, Gesell, Gerver, Goldstein, Hardy, Myklebust, Utley) Table III summarizes the recorded observations on the I Q of 202 children grouped by the etiological classification shown in Table II

REPORT OF FINDINGS

The essential findings in this study are sumarized in Tables I, II, and III More detailed report on the various etiological factors follows

A *Hereditary Deafness*

In this group there were 15 children, or 1 6 per cent of the total number studied Included in this category were children deaf apparently from birth or infancy, whose history revealed at least one sibling with hearing loss in early childhood and/or at least two successive generations in his direct line of descent, with a history of deafness from birth or early life, as suggested by Bordley and Hardy (1951), and no other ascertainable cause The age at first visit ranged from one to ten years, with an average of three plus years The I Q was known in six of these children, four labeled normal, one retarded, and one superior It is of interest that the child with superior intelligence, first seen at age five years, had a hearing loss of 95 db at frequency 512 cycles per second, and gave no response at the higher speech frequencies at maximum intensity of the audiometer The child with mental retardation was first seen at age ten years, and showed a hearing loss of 70, 75, and 80 db in the "vital" speech frequencies (500-2000 cycles per second, inclusive) in the better ear

B *Acquired Prenatal and Natal Causes*

1 *Maternal Rubella*

This group comprised 36 cases with a definite history of maternal rubella early in pregnancy The age range was one to 9 5 years and averaged five plus years at first visit The I Q was known in 26 children, 18 considered normal, five superior, and three retarded Four of these children also had congenital cataracts, two had congenital heart lesions, field that any child "who has not developed speech by the age of two, warrants very careful investigation of his hearing" (Bordley and Hardy. See also Wishart, McFarlan, Lurie, Fowler, Kinney.)

The estimate of intelligence of these children may shed some light on the etiological factors, as it certainly does on

TABLE III

Intelligence Quotient of 202 Deaf Children Tested at Winthrop Foundation

Cause of Hearing Loss	Number Tested	Normal No.	Normal %	Retarded No.	Retarded %	Superior No.	Superior %
A. Hereditary (Familial)	6	4	66.6	1	16.6	1	16.6
B. Aquired Prenatal and Natal							
1. Maternal Rubella	26	18	70.0	3	11.0	5	19.0
2. Rh Incompatibility	17	12	70.6	3	17.6	2	11.6
3. Causes during labor and birth							
a. Prematurity Twins Placenta previa, Toxemia	12	7	58.3	4	33.3	1	8.3
b. Traumatic labor Brain Injury, Cerebral Palsy	19	10	52.6	9	47.4		
c. Cyanosis, Icterus	3	2	66.6	1	33.4		
4. Congenital Anatomical Defects	5	4	80.0	1	20.0		
C. Acquired Postnatal Causes							
1. Meningitis	11	8	73.0	2	18.0	1	9.0
2. Fevers	7	5	71.0			2	29.0
3. Measles	5	5	100.0				
4. Mumps	1	1	100.0				
5. Pertussis	1	1	100.0				
6. Rabies Vaccine	1					1	100.0
7. Skull Injuries	2	1	50.0			1	50.0
8. Middle Ear Disease	6	6	100.0				
D. Cause Undetermined	80	64	80.0	8	10.0	8	10.0
Total	202	148	73.0	32	16.0	22	11.0

their educational potential. Sufficient data was present in the records of 202 of these children to enable us to classify them according to their I.Q. as normal, superior, or retarded. This classification was based, not only on the results of several non-verbal intelligence tests repeated at intervals, but also on reports of educational progress and behavior, made by teachers, parents, social worker, and psychiatrist. The difficulties and techniques of examining the mental capacity of young children with auditory disorders have been stressed by numerentation and weighed 11 lbs at birth In two cases the mother hemorrhaged and was transfused repeatedly during labor, and the children were cyanotic and required oxygen for three and seven days respectively One case was a breech delivery who suffered from neck and foot injuries and was considered to have mongolism The I Q was reported in 19 of these cases ten were classified as normal and nine retarded, (none superior)

c Cyanosis and Jaundice In this group are included three children, aged four, six, and seven years at first visit The four-year-old was cyanotic for several days after birth His intelligence is recorded as normal He was profoundly deaf The second child had delayed respiration for 45 minutes, had an I Q of "low normal," and had hearing loss averaging 60 db in the speech range in the better ear The third child, labeled "retarded," had severe jaundice and convulsions early in life, and showed a hearing loss of 50-60 db in the better ear

4 *Congenital Anatomical Defects*

This group included seven cases They differed from the other groups in having milder hearing losses Four of these children had microtia, three had cleft palate (one of them with microtia and mongolism), and one had cleft palate and harelip Five of these children had conduction deafness (average 50 db in speech range) One child had microtia and profound deafness (90-100 db loss) in one ear, with the other ear normal The average age at first visit was four (range 2-7 years) Five I Q 's were reported four normal, one retarded

C *Acquired Postnatal Causes*

In this category are included 49 children (15 per cent of the total) who were referred to the Clinic for the Deaf Child because of hearing and/or speech difficulties, and who appeared to have had normal hearing and speech development until the intervention of an acute illness or injury

1 *Meningitis and/or Encephalitis* In this group are included 17 cases with a definite history of meningitis and/or

and two were born prematurely and required a prolonged period of incubation

2 *Rh Incompatibility*

In this group were included only those cases with a definite history of Rh incompatibility or kernicterus Most of them were referred to us by hematologists or pediatricians for audiological work-up, the Rh incompatibility having been established by them prior to referral to us There were 23 children ranging in age from one to 7 5 years (average age 4 5 years) The I Q was reported in 17 cases 12 normal, two superior, and three retarded Three of these children were born prematurely (two of them had cerebral palsy, and one had a sister who was born blind) Six of the children in this group had cerebral palsy, and one was epileptic The three children classified as retarded fell into this latter group

3 *Causes During Labor and Birth*

a Prematurity, twin births, placenta previa, toxemia of pregnancy In this group are classified 18 cases with an age range of one to eight years (average four years) All of them have a history of premature births requiring incubation and oxygen postnatally Three of these were also twins, two were placenta previa cases, and four cases gave a history of toxemia during pregnancy The I Q in 12 of these was known seven normal, one superior, and four retarded

b Traumatic labor, (Brain injury, cerebral palsy) This group, the second largest with known etiology in this study, contained 29 cases in which the cause of hearing loss was ascribed to the trauma of difficult prolonged labor, with the life of the child or mother greatly endangered Their age, at first visit to the Winthrop Foundation, ranged from one-and-one-half to seven years and averaged four years Fifteen of these showed difinite evidence of brain injury cerebral palsy, convulsions in neonatal life, monoplegia, limb injuries, prolonged cyanosis, etc Several of them required prolonged resuscitation Four were difficult breech deliveries One case, a face presentation, had malformation of the cervical and dorsal vertebrae (Weil syndrome) In two cases, the mother died during labor One child was a transverse presthe petrous pyramids. One four-year-old gave a history of "skull fracture" in infancy, and showed a hearing loss of 10 to 70 db in the speech range; however, in this case there was also a history of difficult labor. The other two children, aged two-and-a-half and three years when first seen, gave a history of head injury at age two, with subsequent unsteady gait and showed "absent caloric tests" and profound deafness.

C. Middle Ear Disease. This category includes seven children with otitis media and moderate deafness who presented special problems of rehabilitation and, therefore, were not treated in the regular outpatient clinic, but were referred to the Winthrop Foundation for follow-up. In two of these, the diagnosis of possible otosclerosis was made and they will be followed at the Winthrop Foundation. The I.Q. in six of these was determined—all normal.

D. Cause Undetermined.

Unfortunately in the largest group of these children, 148 or 45 per cent of the total studied, we were unable to determine the cause for reasons partly explained above. They ranged in age at the first visit from one to ten years, with an average of four years. The I.Q. was reported in 80 of these children—64 normal, eight superior, and eight retarded.

COMMENTS AND DISCUSSION

Several findings in this study deserve comment. The first is the age when competent otological help was sought. It is unfortunate that less than one-third of these children were examined before the age of three, and only about 50 per cent before the end of the fourth year. This bears out the statements of Wishart that "the ignorance regarding the importance of hearing in a child under two years of age is appalling. . . . The majority of congenitally deaf children come to the clinic too late and go to preschool training class without any training in lip-reading and with voices that are dull, flat and lifeless. This occurs because two essentials in their training have been missed. It has not been started early enough nor has it been done by the potential teacher every baby has, its mother." He advises that "the mother should start the train-encephalitis with subsequent hearing loss. Four of these had known meningococcal meningitis, three had pneumococcal meningitis, one had tuberculous meningitis and one had influenzal meningitis. The other cases had been diagnosed as "meningitis" by the referring physician, but the organism is unknown. Two of the children had associated paralysis, one had temporary hydrocephalus. Most of them were profoundly deaf. They ranged in age from two-and-a-half to six years (average four-and-a-half years). The I.Q. is reported in 11 cases: normal in eight, retarded in two, and superior in one. The one "superior" child, a case of influenzal meningitis, was six years old when tested, and had a mental age of ten years. He was profoundly deaf (75, 85, and 90 db. loss in the vital speech frequencies in the better ear).

2. *Acute Febrile Disease.* Eleven cases. Age range one to seven years, average three-and-a-half years. I.Q. reported in seven cases: five normal, none retarded, two superior. Four had pneumonia, two had severe "virus" infection, and the others had an acute febrile disease of undetermined etiology.

3. *Rubeola.* Six cases, age range two to six years, average four years. I.Q. reported in five—all normal. Two of these children had only unilateral nerve deafness, and one had a bilateral mild nerve deafness, two had partial deafness (average 70 db. loss in speech range), one had profound deafness.

4. *Parotitis.* There were only two cases of deafness following mumps, (ages four and six years) one averaging 55 db. loss and the other 90 db. in speech range.

5. *Pertussis.* One case, aged three, normal intelligence, with mild nerve deafness (20-30 db. in speech range).

6. *Rabies Vaccine.* There was one child, of superior intelligence when first tested at age of five years, whose profound deafness followed 21 "Pasteur treatments" at the age of two years.

7. *Skull Injuries.* Head trauma was the cause of hearing loss in four children. One child, first studied at age nine, had superior intelligence, and a hearing loss averaging 80 db. in the speech range as a result of bilateral fracture through

Table IV shows comparative etiologic data of several recent reports. Under the heading "Labor and birth" are included cases of deafness ascribed to toxemia, prematurity, and birth injuries.

The variations in the incidence of the causes of infantile deafness is often striking. An etiologic diagnosis can seldom be made with any degree of certainty since, as Fowler has pointed out, "the reasoning used to classify the groups is '*post hoc propter hoc*' reasoning." Some of the reports cover only cases studied in schools for the deaf (Best), others in otological centers (Bordley). Some include mainly severe nerve deaf cases (as in this study), others include milder cases of mixed deafness or conduction deafness. Statistical comparisons are, therefore, inaccurate and may be misleading; however, it is becoming clear that, with our newer knowledge of the potential *in utero* causes, heredity as a cause has been greatly exaggerated in past reports. Too many cases have been loosely labeled "congenital" or hereditary.

TABLE IV

Etiologic Data Compiled from Recent Reports
(Per cent of number reported)

CAUSE	Unknown	Heredity	Maternal Rubella	Rh Incompatibility	Labor and Birth	Meningitis	Measles
Present Study	45	4.6	11.0	7.0	14.5	5.2	2.0
Bordley (1952)	30	4.0	5.0	6.0	4.0	9.0	6.0
Goodhill (1950)			20.0	3.0		10.3	
Fowler and Basek (1954)		3.7	4.5	4.5	9.0	4.0	5.0
Kinney (1953)	43.3	14.6		2.2	3.8	4.8	17.3

In this study, as in other recent reports (Bordley, Kinney), there was not one case caused by syphilis.

We were impressed with the high incidence of deafness ascribed to the difficulty of labor and birth in our series. Certainly most of these cases can and should be prevented

ing as soon as the defect is suspected, perhaps at s
of age, and that special education should be started,
at the age of two, and certainly at the age of thre
early critical years are lost the child's opportunit
fluent speech is lost forever " Otologists must
doctor, and especially the pediatrician, that it is
importance to detect deafness and to start trai
in life as possible (Ewing), and that this can
first year of life (Whetnall, Richmond et al)

McFarlan, in discussing Wishart's excellen
out that in the handling of the deaf child "
mistakes are to say, 'wait until the child grow
still, to diagnose a 'mental retardation' "
out the findings of numerous observers tha
of the deaf child is comparable to the nor
(Gesell, Gerver, Hardy, Heider, Lassman,
Strauss, Streng et al) Seventy-three pe
children whose I Q was reported in this stu
intelligence, 16 per cent were "retarded'
were "superior " The greatest incidence
found in the children injured during the
this tragic complication is preventable

The etiologic diagnosis of deafness in a you
difficult even after a careful history and otolo
because of the absence of pertinent informatio
accumulating knowledge of the numerous pote
infantile deafness, especially during the prena
neonatal period, has not been adequately dissem
the medical profession and others concerned with
of children Otologists have a continuing duty to
this knowledge, and in the words of Dr Fowler, Sr ,
the gospel of early detection" to all concerned

The large percentage of cases of undetermined cause
cent in this study) has been mentioned Kinney (19
alyzed 630 "partial perception cases," and was unable
termine the cause in 43 3 per cent Bordley's "Analys
etiologic factors underlying impaired hearing of 485 child
(1952) showed 140 cases of undetermined cause (30 per cen

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Perhaps, here lies the major urgent indication for dissemination of knowledge regarding the etiology of infantile deafness among all physicians and the interested laity Much public health work can be done to prevent the scourge of infantile deafness from erythroblastosis, German measles, the trauma of labor and delivery and from most of the acquired postnatal causes Next to prevention, the most pressing need is early detection of deafness (during the first year of life) and the initiation of rehabilitation in the first years of life

SUMMARY AND CONCLUSIONS

The records of 328 deaf children studied at the Winthrop Foundation of the Massachusetts Eye and Ear Infirmary are analyzed as to etiological factors

The causes of deafness, the age at first visit, and the I Q of 202 of these children are reported

The difficulties in making a precise etiologic diagnosis are pointed out The large number of cases with "cause undetermined," is discussed and partly explained

The study points out that the intelligence of deaf children as a group is comparable to normal hearing children

The importance of early detection of infantile deafness and the need for early training is stressed

The duty of otologists to disseminate widely the recently acquired knowledge as to the etiology of deafness in early childhood is emphasized, and the possibilities of prevention of most of the causes of infantile deafness are noted

The pertinent literature is reviewed and a bibliography is appended

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EUSTACHIAN TUBE FOREIGN BODY

Report of a Case*

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Reports of foreign bodies retained in the Eustachian tube have been rare since bouginage and electrolytic treatments of the tube have lost favor Broken bougies remaining as foreign bodies in the Eustachian tubes have been reported by Wendt (1869),[3] Andry and Reynolds (1880),[3] Harris (1901),[1] Tansley (1902),[11] Duel (1903),[2] Philips (1905),[8] Simpson (1905),[9] Stimson (1915),[10] Hastings (1937),[5] and Mangiaracina (1940)[6] The bougie tip had remained in the Eustachian tube of Hasting's patient for 20 years In the discussion of a paper by Harris in 1904, Dench[1] reported having seen three gold bougie tips removed from a single ear at one time

In a review of the literature written in 1920, Guthrie collected the following unusual foreign bodies of the Eustachian tube [3]

1. A grain of rice reported by Urbanschitsch in 1878
2. A sewing needle reported by Schwartze in 1885
3. A straw reported by Camerer in 1897
4. A cherry stone reported by Trautman in 1898
5. A stalk of grass reported by Piffl in 1907

This case is similar to one reported by McNaught in 1948, in which a piece of slag lodged in the Eustachian tube after having been washed through a perforation in the tympanic membrane[7]

A 24 year old welder was seen in September, 1956, because of severe pain and drainage in the right ear since swimming two weeks before The history revealed that a piece of slag had lodged in his right ear canal

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while he was welding three months previously The slag was removed by irrigation of the ear canal in a doctor s office This was very painful to the patient and was followed by discharge and severe pain Under antibiotic therapy the pain gradually subsided, and the discharge stopped Considerable hearing loss had been present since the original injury

Physical examination revealed copious pulsating purulent discharge in the right ear canal issuing from an anterior inferior marginal perforation of the drum Marked tenderness was present over the mastoid process The nasal septum was deviated to the right and the nasal mucosa was diffusely inflamed with mucopurulent post nasal discharge The examination was otherwise within normal limits The clinical diagnosis of acute otitis media and mastoiditis was confirmed by radiographs The films also revealed a metallic foreign body lodged at the isthmus of the right Eustachian tube (see Figs 1, 2)

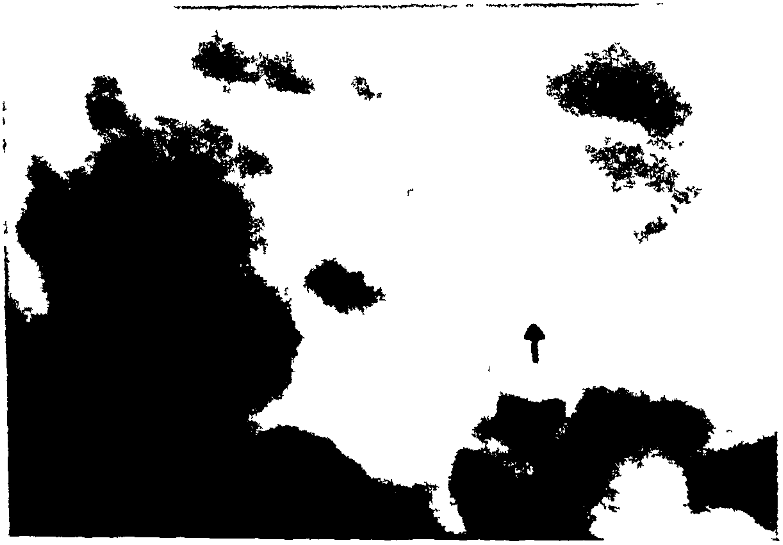

Fig 1 Stenvers Position The arrows indicate the metallic foreign body lodged at the isthmus of the Eustachian tube

Treatment was instituted with antibiotics The pain and discharge rapidly subsided When the ear was dry, audiometry revealed a normal bone curve and an average of 40 decibel loss for the speech frequencies by air conduction.

An attempt to dislodge the foreign body by direct inflation was unsuccessful Considerable force was necessary to dislodge it with an Eustachian tube bougie The fragment was then blown into the tympanic cavity by direct inflation and was removed with a suction tip through the perforation of the tympanic membrane The ear remained dry but attempts to close the perforation by cautery of its edges and patching proved futile A myringoplasty was recommended The insurance company referred the patient to another otolaryngologist who concurred in this recommendation

The patient again consulted the physician who had originally removed the slag from his ear canal This doctor recommended against surgical closure of the drum, and myringoplasty was subsequently refused by the patient

Interestingly enough, the patient has since been treated elsewhere for a slag burn of the left external canal and tympanic membrane This perforation closed spontaneously

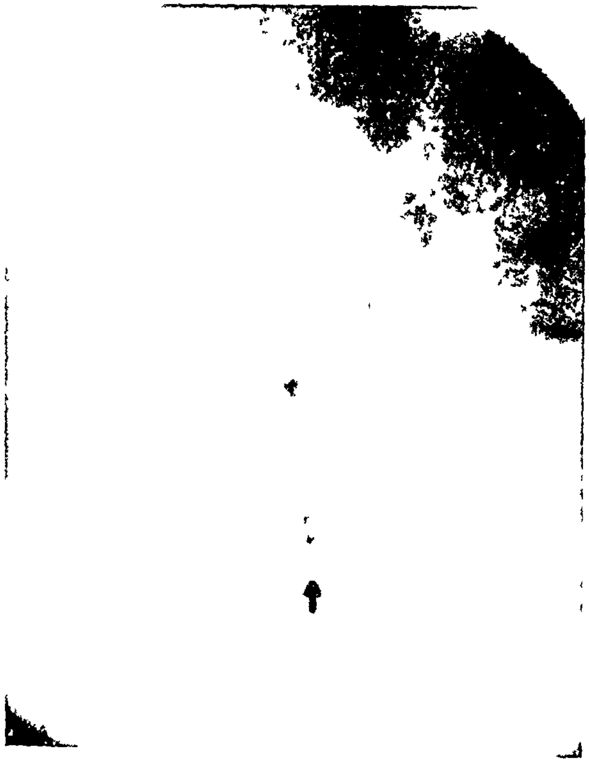

Fig 2 Mayer's Position The arrows indicate the metallic foreign body lodged at the isthmus of the Eustachian tube

CONCLUSIONS

1 Since slag lodged in the external canal is frequently associated with perforation of the tympanic membrane, irrigation of the ear canal for the removal of the foreign body is definitely contraindicated In addition to the danger of introducing infection there is the additional hazard of washing small fragments of the foreign material into the tympanic cavity and Eustachian tube

2 In spite of the infrequency of reports in the literature, when slag burns of the tympanic membrane are accompanied by prolonged infection, or when surgical closure of the perforation is contemplated, radiographs should be taken to search for foreign bodies located within the osseous portion of the Eustachian tube

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CLOSED CERVICAL TRACHEAL FRACTURE
A CASE REPORT

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Closed tracheal injuries are not frequently reported in surgical literature The management of tracheal lacerations are well covered in recent reports A number of authors give detailed reviews of surgical repairs, either by primary anastomosis, or with various prostheses bridging tracheal defects in lacerating or avulsive trauma

The following authors[1 2 3] have laid down the basic steps in the care of tracheal injuries and also give a review of complications and management

The following case of tracheal fracture, resulting from a closed injury, was managed "conservatively," with an excellent clinical response and without posttraumatic sequelae

This case is reported for interest, and should not deter from other methods of care in these injuries

For review purposes, this injury is caused by compression or impact of the trachea in a closed space The cartilaginous membrane is usually torn, with or without fracture of the tracheal rings themselves[4]

This report is of an interesting case of closed tracheal fracture, treated without surgical intervention

The patient, a 24 year old white woman, was admitted to a local hospital, (San Antonio, Tex), on October 25, 1955, following an automobile accident She sustained a chin laceration, contusion of the neck, and shortly after admission developed cervical subcutaneous emphysema

Physical examination revealed a blood pressure 130/72, pulse 86 regular, respiration 24, no cyanosis The patient was not in shock Positive findings were of a chin laceration, contusion of left anterior lateral neck, middle third, and crepitus of the soft tissues anterior to the trachea and bordering laterally by the borders of the sternomastoid The crepitus extended superior to the hyoid bone and inferiorly into the suprasternal notch There were no other objective or subjective findings

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Laboratory data Hemoglobin 15 1, white blood cells 13 120, polys 76, lymph 16, stabs 2, monocytes 1 urinanalysis, specific gravity 1,014 alkaline reaction, negative sugar and albumin

Hospital course Patient placed on penicillin 800,000 units twice daily, and streptomycin 1 0 gm daily Roentgenogram of thorax and cervical area revealed clear lung fields and cervical subcutaneous emphysema in the anterior and middle compartments of the neck

October 29, 1955, the patient's hoarseness was disappearing, cervical emphysema decreasing and she was afebrile On November 5, 1955, the hoarseness was improved the cervical emphysema was almost absent Lung fields were clear on fluoroscopy and the vocal cords moved on respiration and appeared intact Antibiotics were discontinued, and patient was discharged from the hospital

She was seen in the office on November 26, 1955 Indirect laryngoscopy revealed intact cords, no edema Fluoroscopy revealed clear lung fields and movable vocal cords on phonation She noted that she occasionally had episodes of hoarseness which lasted one or two hours, and then gradually subsided

The patient was last seen on January 5, 1956 the voice completely normal no induration in the neck and clear lung fields on fluoroscopy examination

CONCLUSION

This case is reported as a matter of interest The closed tracheal fracture was treated without surgical intervention, and with a satisfactory clinical response

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PHENYLBUTAZONE AS AN ADJUNCT IN THE TREATMENT OF ACUTE OTITIS EXTERNA AND OTHER EDEMA OF THE EAR, NOSE AND THROAT

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Edema associated with allergy and angioneurotic edema specifically is not considered in this paper. Depending upon the etiology, traumatic or infectious edema is usually managed with both local and general measures. These involve the use of hot or cold applications locally, wicks, compresses, drops, ointments and the various antimicrobials, generally, the relief of pain and oral or parenteral antibiotics. The past few years have witnessed the advent of the usual anti-inflammatory agents such as the proteolytic enzymes in local, oral and intramuscular forms, and the various modifications of the Cortisones.

This discussion limits the pathologic states described to the edema associated with acute external otitis, either primary, or secondary to a primary otitis media, furunculosis of the nose, after nasal operations such as rhinoplasty and septectomy and acute thyroiditis (see chart). Even with careful technique and minimal trauma when cleaning the external auditory canal, for example, and using a judicious combination of the above named agents, the average time for subsidence of edema was six to nine days, occasionally lasting as long as three weeks in several stubborn cases of external otitis secondary to otitis media, however, using the same agents as indicated, but without enzymes or hormones, and with Butazolidin,® the edema in external otitis, for example, subsided in 48 to 72 hours, and in practically all cases in which it was used within four or five days at the most. As can be seen in the chart, edema either did not develop at all or lasted only a few hours in the nasal cases, without Butazolidin© and

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using other anti-inflammatory agents, swelling required an average of five to seven days to subside. With phenylbutazone the edema of the painful and completely shut canal was controlled so rapidly that usually by the second office visit, two days after onset of treatment, the lumen was large enough to allow a more thorough cleaning of the depths, thus, facilitating resolution of the infection.

With the use of the proteolytic enzymes disadvantages may be noted: vagaries in buccal or sublingual absorption, pain at the site of injection, and tendency to serious allergic reactions.[1] The first two are particularly noted in children. The expense of hormones and tendency toward temporary increase of edema with these hormonal products, is also to be considered. On the other hand, these disadvantages are minimized, and more accurate dosage obtainable with the oral route is important.

CHART

Type of Case	No. of Cases Routine Treatment Including Enzymes and Hormones	Average Duration of Edema	No. of Cases New Using Butazolidin®	Average Duration of Edema
Acute Primary External Otitis	28	6.9 days	59	3.5 days
Acute External Otitis Secondary to Acute Otitis Media	5	1-3 wks	5*	3.4 days
Nasal Furunculosis	7	5.7 days	6	2.3 days
Rhinoplasty	3	4.5 days	2	24 hrs
Septectomy	5	6.7 days	3	12-18 hrs
Acute Thyroiditis	3	1.3 wks	2	2.3 days

*These five are the same first treated routinely and then finally with phenylbutazone.

Butazolidin® for adults is begun with either the 100 mgm. tablet or the Alka capsule form after first obtaining a negative history of peptic ulceration, anemia or allergy.[2] A total of 600 to 800 mgm. is given the first day on a full stomach, with a decrease to 400 mgm. for the next two days. Should the individual case require it, the last dosage may be continued for another three days. The dosage for children is proportionately smaller. The salt intake should be restricted. This short duration of treatment also tends to decrease the frequency of side effects.

In the group of cases under discussion the only reactions noted were gastric upsets in two patients These improved when the Alka capsule was substituted There were five cases of particular interest to the otologist these were cases of acute otitis media submitted to myringotomy and subsiding with appropriate treatment after culturing and sensitivity testing for the most effective anti-microbial After a period of time varying from five days to three weeks, the discharge from the middle ear was the immediate exciting cause of a fulminating external otitis obscuring the healing drum membrane In all five cases Butazolidin® effected a rapid subsidence of canal inflammation and edema, and the drum was found intact after treatment

Only two of the more interesting ear cases will be mentioned briefly here one finally remembered a history of external otitis treated nine months previously without sequellae and dry until after myringotomy, the middle ear discharge apparently lighting up a dormant canal infection The second case involved a diabetic in whom the middle ear discharge and canal infection did not subside for three weeks after onset of intensive specific treatment, and in desperation phenylbutazone was used in the above mentioned doses with the result that complete healing of the drum and subsidence of the external canal infection occurred in three days while still using the original antibiotic Two patients in whom the clinical diagnosis of acute thyroiditis was made by finding a slight to moderate swelling of one or both lobes of the thyroid gland associated with exquisite tenderness of the involved areas very rapidly cleared of symptoms under Butazolidin® and refused to undergo further diagnostic tests An interesting finding in two patients not sought for, with relief of edema in mind, was a complete disappearance of facial acne This could be attributed to the anti-inflammatory action of the phenylbutazone and suggests further investigation One patient stated that even the pores of the skin about the nose and forehead were much smaller

SUMMARY

1 Drug for drug, phenylbutazone is the most potent and effective anti-inflammatory agent with non-hormonal advantages yet offered for edema, traumatic or infectious, of the ear, nose and throat It does not disrupt endocrine function, and it is not dependent upon it

2 Used with precaution and due regard for anemia, allergy and peptic ulcer tendency it is safe and without side effects

3 By rapid absorption of edema in diffuse external otitis cleaning and more effective treatment can be accomplished within two or three days

4 In stubborn cases of external otitis associated with otitis media that do not resolve readily by the usual methods, phenylbutazone was found to stop completely the drainage from the middle ear while still using the original antibiotic, and facilitate canal resolution within three to five days after starting therapy

5 The mechanism of action is as yet not elucidated, but its effectiveness is so rapid that further study is warranted with a view to extending its field of action and application, particularly to other head and neck edema, including laryngeal inflammation

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TRANSMISSION LOSS ACROSS THE SKULL IN A PATIENT WITH KNOWN TOTAL MONAURAL DEAFNESS †‡

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SURVEY OF THE LITERATURE

Several writers have reported their findings on the transmission loss across the skull which occurs for air conducted sounds These reports are of importance clinically because they are used in determining under what conditions a masking noise should be presented to the non-investigated ear for pure tone air conduction measurement

Fowler[1] found that at 45 db or more over the normal threshold the opposite ear receives speech sounds by cross-audition Fowler[2] states in another reference that an air conduction masking sound above 35-50 db , depending on frequency, is sufficiently intense to be sensed by the contralateral ear (at its threshold or above) if the bone conduction in this contralateral ear is not sufficiently depressed to prevent it Hughson and Westlake[3] state that cross-hearing is likely to occur if an individual has a difference between the two ears of 30 db or more Sparrevohn[4] breaks down the transmission loss at individual frequencies 21 db at 128 cycles, 23 db at 256 cycles, 19 db at 512 cycles, 34 db at 1024 cycles, and 34 db at 2048 cycles Saltzman[5] suggests that 50 db represents the loss for air conducted sounds through the head uniformly at all frequencies Tschiassny[6] reports an attenuation increasing with frequency averaging 55-75 db in two monaurally deaf patients If the healthy ears were kept closed, the loss decreased to the level of 35 to 60 db Weille

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and Gargano[7] claim that about 50 db are required for sound to go around the head to the opposite ear if it is covered by a well-fitting earphone, but do not specify the transmission loss for specific frequencies

The difference in findings by the investigators quoted on the degree of transmission loss across the skull may be due to one of the following factors *1* Inter-individual variations in the impedance of different skulls, *2* differences in the degree of deafness present in the supposedly deaf ear in the subjects used and possible slight differences in the hearing of the non-investigated ear, and *3* the sound isolation provided by the different earphones used

TABLE I

Transmission Loss Across Skull in a Patient with Total Monaural Deafness

	Right Ear	Left Ear
Frequency	Point at which Response was Elicited in Normal Ear	Hearing in Better Ear
125 cycles	45	0
250 cycles	45	–5
500 cycles	55	0
1,000 cycles	65	0
2,000 cycles	65	25
4,000 cycles	60	20
8,000 cycles	80 +	50

REPORT OF CASE WITH TOTAL MONAURAL DEAFNESS

The patient is a 24 year old private first class in the Army, on the neurosurgical ward of the main section of the hospital, who was referred to the investigator by the Chief of the Ear Nose and Throat Section He had known total deafness in the right ear, resulting from an automobile accident in which both the acoustic and vestibular branches of the VIIIth cranial nerve were totally destroyed on the affected side Vision and vestibular responses were completely absent on this side The patient reported a constant tinnitus in his right ear The otologist in charge* was of the opinion that the presence of tinnitus could be explained on the same basis as the tinnitus which is sometimes present when the VIIIth nerve is severed surgically[8] Pure tones were introduced through an earphone over the patient's deaf ear in the orthodox manner, and the point at which the normal ear picked up these sounds was recorded for each frequency These readings give us an idea of the transmission loss across the skull for air conducted sounds in this patient The results are shown in Table I

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The results of testing 8,000 cycles by air conduction showed no response at the maximum level of the audiometer At this frequency, however, a loss of 50 db was present in the better ear A slight loss was present at 2,000 cycles and 1,000 cycles, and the transmission loss across the skull is the figure shown minus the degree of loss in the better ear, *i e*, 2,000 cycles 65 minus 25 db equals 40 db and 1,000 cycles 60 minus 20 db equals 40 db This gives us an average transmission loss of 53 db for the three mid frequencies

SUMMARY

The literature on the transmission loss across the skull which occurs for air-conducted sounds is reviewed A case of known total monaural deafness is reported The attenuation loss across the skull for air-conducted sound, determined by testing the impaired ear without masking, is shown The attenuation loss for air-conducted sound varies at different frequencies The amount of masking used for air-conduction measurements should be varied according to the frequency tested

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PROGRAM FOR THE SCIENTIFIC SESSION OF THE THE AMERICAN LARYNGOLOGICAL, RHINOLOGICAL AND OTOLOGICAL SOCIETY, INC

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"Neck Dissection A Clinico-Anatomical Study of 200 Cases"
George F Reed, M D, Boston, Mass

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John J O'Keefe, M D, Philadelphia, Pa

Open Discussion

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"Cystadenolymphomas of the Parotid Gland"
John F Daly, M D, New York City

Open Discussion

"Experience with Trans-Septal-Sphenoid Subtotal Hypophysectomy in Advanced Breast Cancer"
Walter E Heck, M D, Robert C McNaught, M D; Leonard G Dobson, M D, (by invitation), and Francis S Greenspan, M D, (by invitation), all of San Francisco, Calif

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Henry Perlman, M D , Chicago, Ill
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Bruce Proctor, M D , Detroit, Mich
Open Discussion

"Juvenile Nasopharyngeal Angiofibroma"
Maurice Schiff, M D , Oakland, Calif
Open Discussion

"Late Hearing Results in Mobilization Surgery"
Samuel Rosen, M D , New York City, and
Clair M Kos, M D , Iowa City, Ia
Open Discussion

"Trends in Mobilization Surgery"
Howard P House, M D , Los Angeles, Calif

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PROGRAM OF THE NINETY-SECOND ANNUAL MEETING OF THE AMERICAN OTOLOGICAL SOCIETY

Hot Springs, Va , March 13-14, 1959

The Cochlear Potentials and Their Relation to Hearing
E Glen Wever, Ph D

More About the Physiology of the Cochlea
Hallowell Davis, M D

Audiometry by Electroencephalography
A J Derbyshire, M D (by invitation)

Ototoxicity of Kanamycin
J E Hawkins, Jr , Ph D (by invitation)

A Cause of Sudden Deafness
William Saunders, M D (by invitation)
William Libby, M D (by invitation)

Acoustic Trauma Following Intermittent Exposure to Tones and Noise
Walter Covell, M D (by invitation)
Don Eldredge, M D (by invitation)

An Experimental Study of the Dynamic Circulation of the Labyrinthine Fluids of Living Mammals.
Francis L Welle, M D ,
John W Irwin, M D (by invitation)
Coza Jako, M D (by invitation)
Patricia Palmer, A B (by invitation)

Long Term Results from Surgery for Otosclerosis
Theodore E Walsh, M D

Ultra-Sonic Therapy of Meniere's Disease
Franz Altmann, M D

Presbycusis
Edmund P Fowler, M D

Nihil Sub Sole Novum
Lyle Sellers, M D

Otic Embryopathy
George Kelemen, M D

Cochlear Blood Flow in Hypothermia
H B Perlman, M D ,
Robert Butler, M D , and
Robert Kimura (by invitation)

Postural Mystagmus Produced by Cerebellar Lesions in the Cat
Cesar Fernandez, M D (by invitation)

Fluid Ears and Nerve Deafness, Circa 1835
Gordon Hoople, M D
Wesley H Bradley, M D (by invitation)

Tympanoplasty
Fred Guilford, M D

Surgical Treatment of Facial Paralysis and Associated Conductive Deafness in Fracture of the Temporal Bone
H E McHugh, M D

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Weaker, more distant sounds become audible when the hearing loss is corrected in both ears A child's voice, which may be barely heard at 10 feet with one ear, becomes easily audible at 30 or 40 feet with two-ear hearing

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As measured by P B and Spondee Word Tests, the patient's word score with binaural hearing improves in the vast majority of cases Words, phrases – all sounds – are clearer when heard with both ears This is especially true when hearing is accomplished in the presence of annoying background noise

Determines Direction of Sound

With just one-ear hearing, the patient tends to hear everything in one ear – all sounds seem to originate from one side Two aids restore the sense of sound direction that the nor hearing person enjoys This improvement important benefits in traffic safety, good c versation, and other similar situations

Needs Less Power

Increased understanding of sounds, depth, and direction perception add up wi or four times better hearing binaurally W both ears are fitted with an aid, the always finds he needs less volume and po so that listening is more comfortable and r ful At the end of a busy day he is not ti out from straining and trying to hear

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MAXILLECTOMY IN CARCINOMA OF THE ANTRUM*

An Analysis of 81 Cases and a Description of Certain Modifications of the Basic Technique of Extirpation†

HAROLD G TABB, M D ,

New Orleans, La

Many years ago a very brilliant surgeon, whose name regrettably I cannot recall, made a very wise observation to the effect that repetition of the same ideas does not necessarily mean paucity of ideas It may quite as well, he said, mean intensity of conviction On that basis, I return again to the subject of carcinoma of the antrum, to stress several of the things which I have already said in previous papers on this subject

My thesis is briefly this

1 At the best, the results in malignant disease of the antrum will never be very good, because the cards, to use the vernacular, are stacked against both patient and physician The structural continuity of the area is an invitation to the rapid spread of disease processes When the ethmoid area is involved, brain tissue is only a few millimeters away; furthermore, malignant growths in this area are predominantly of the epidermoid or squamous-cell variety and are usually of a high grade of malignancy

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†From the Department of Otolaryngology Tulane University of Louisiana School of Medicine

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2 Bleak as is this outlook, we should not accept the situation with an attitude of frustration and futility, instead, we should regard it as a challenge. The regional anatomy is immutably fixed, but immediate and long-term results can be improved if all physicians will employ a high index of diagnostic suspicion, and if all surgeons who encounter the disease will treat it with imagination and courage. Neither of these objectives is impossible of attainment.

DIAGNOSTIC CONSIDERATIONS

Patients with carcinoma of the antrum are seldom seen early. A delay of three months after the onset of symptoms is average. A delay of six to nine months is frequent, and delays of a year or more are not infrequent. This is an insidious disease, and the same reasons that make patients delay in seeking medical consultation make physicians delay in diagnosing it.

The etiology of antral cancer is still unsettled, but there is no doubt that it is definitely related to, and often appears in association with, diseases of the nasal tract and paranasal sinuses which are benign in most cases, and which it is the tendency to regard as benign in all cases. The patients have become accustomed to the existence of these diseases. The physicians whom they consult are accustomed to managing them as benign, and they treat the patients, therefore, with the purpose of relieving symptoms without investigating the pathologic process. Otolaryngologists often fall into this error.

These are serious fallacies. Chronic sinusitis, various allergies, polyps and nasal obstructions all interfere with local ventilation and drainage and create what might be termed the climate of malignancy. Because of the frequency with which nasal and other polyps prove malignant on histologic examination, it is now our policy that all these and other masses, whether they are demonstrable grossly or can be demonstrated only by roentgenograms, should be removed and examined under the microscope. There is a dangerous impression among many otolaryngologists, as well as among other physicians, that a projecting mass in the sinuses, if it is smoothly contoured and is not producing symptoms, is harmless and requires no treatment This is not a safe policy. Similarly, we have come to believe that it is wise to remove all severe obstructive deviations of the nasal septum, because of the conditions which they set up by their interference with normal ventilation and function

The wisdom of this policy was brought sharply home to me by the case of a 39-year-old white man who underwent routine submucous resection for a severe deformity of the septum Under the obvious lesion lay an early carcinoma which was apparently just beginning to invade the maxillary sinuses Radical maxillectomy was performed a few days after the first operation, and the patient, seven years and four months later, is still living and well His case is one of the few that *does* prove, and one of the larger number that *could* prove, that carcinoma of the antrum is a curable disease when it is found early enough to permit radical removal of the growth with an adequate margin of normal tissue around it

A far less happy instance was also an accidental diagnostic discovery A 16-year-old Negro, hospitalized for a football injury of the orbital, nasal and ethmoid bones, had a large, mucosa-covered mass in the right nostril It was regarded as a hematoma until biopsy prove it to be malignant Radical maxillectomy was performed, but the growth was a rapidly growing rhabdomyosarcoma, and the boy died two months later

Diagnostic Regimen

Certain symptoms and signs require a diagnostic survey without delay, in spite of the fact that they are also, at least in their early, milder, manifestations, the symptoms and signs of malignant disease They are as follows

1 Unilateral nasal masses, with widening of the nasal bridge, or unilateral swelling and tenderness in the nasal area

2 Polypoid masses in the nose and sinuses, particularly masses which have been present for a long time Abnormally

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1 Unilateral nasal masses, with widening of the nasal bridge, or unilateral swelling and tenderness in the nasal area

2 Polypoid masses in the nose and sinuses, particularly masses which have been present for a long time Abnormally free bleeding when they are removed should be viewed with deep suspicion

3 Prolonged unilateral nasal obstruction, with a blood-tinged discharge or frank epistaxis

4 An intractable purulent sinus infection which does not respond to adequate therapy

5 Pain in the cheek or upper teeth out of proportion to the clinical findings

6 Tender swellings of the palate and antral area

7 Ocular proptoses

As this list of symptoms and signs implies, the patient who suffers from them will not always be seen first by an otolaryngologist Dentists, ophthalmologists and other physicians must also come to realize the occasional lethal potentialities of these usually innocuous findings

The steps of a correct diagnostic survey include

1 A careful local examination

2 Nasopharyngoscopy

3 Roentgenologic examination Roentgenograms in early malignant disease show only opacity, and the shadow cast by an antral cancer, which is a soft-tissue growth, cannot always be distinguished from the shadow cast by a benign lesion Later, increased density of the sinuses or nasal cavities is followed by evidence of bony expansion or destruction

4 Cytologic examination by the Papanicolaou technique This is a misleading method unless it is constantly borne in mind that while a positive result is conclusive, a negative result is not, and must not be so regarded

5 Aspiration biopsy, for which the same warning holds

6 Surgical biopsy, repeated if it is negative

7 Surgical exploration, which must be undertaken if the suspicion of cancer persists in the face of repeated negative biopsies The pathologist must be supplied with a representative section of tissue and must be given ample time to study it The surgery of antral cancer is radical mutilating surgery It is disastrous not to employ it when malignant disease is present, but equally disastrous to employ it when it is not

SURGICAL CONSIDERATIONS

Over the last several years, there has come to be fairly general agreement that surgery, followed by irradiation, offers the best chance of survival for the patient with cancer of the antrum The mortality of surgery was once distressingly high, immediately from shock and blood loss, and a little later from meningitis Irradiation was, therefore, the method most generally used, as the lesser of two evils, but irradiation, without excision of the malignant growth, gives rise to serious complications, particularly when the bone has been invaded, and the surgical procedures necessary to control these complications must often be quite as radical as though surgery had been employed primarily

Total removal of the maxillary sinus is necessary if cure is to be achieved in carcinoma of the antrum Total removal of the sinus is impossible without total removal of the maxillary bone Any surgery which is not based upon this fundamental concept is not adequate surgery Surgery of such magnitude is now entirely practical, thanks to improved techniques of anesthesia, including hypotensive anesthesia, the liberal use of whole blood, now available in hospital blood banks and the development of efficient wide-spectrum antibiotics

Basic Technique

The basic technique of the radical operation for carcinoma of the antrum has already been published,[1] and I shall not describe it in detail Instead, I shall merely list the principal steps of the operation and call attention to certain modifications employed in the most recently treated cases

The Weber-Fergusson incision is used to expose the facial surface of the maxilla, and the entire maxillary bone, with the maxillary sinus, ethmoids, and orbital contents, is removed *en bloc* To accomplish this, the palate is split in the midline, and the maxilla and portions of the zygoma and ethmoid bones are separated from their attachments The sphenoidal, frontal and posterior ethmoids are curetted and fulgurated, as are all other suspicious areas It is generally preferable to include the eye in the dissection unless an undoubtedly clear margin of normal tissue can be demonstrated between it and the lesion If there is any doubt, the eye must be sacrificed During the operation, the entire cavity is irrigated with a cancerocidal solution, to reduce the number of viable cancer cells in the wound washings

Modifications

The following modifications of the original technique have been introduced over the last three years

1 The electric saw instead of the Gigli saw is used to section the zygomatic bone, the infraorbital rim and the coronoid process of the mandible With it, bone section is accomplished more rapidly and with less effort

2 Ligation of the internal maxillary artery is still attempted routinely, but the omission of this step seems to be attended with little additional risk, and ligation is, therefore, abandoned if the artery lies deep to the pterygoid muscles and is difficult to identify

3 We still prefer to employ the technique of hypotensive anesthesia devised by Adriani, but we have no illusions concerning its risks, and we now omit it in older patients or in patients who are poor surgical risks

4 In the original technique, the mucosa over the hard palate was removed with the palate We now salvage the membrane whenever the antral floor is not involved in the malignant process It frequently is not, since most cancers in this anatomic area grow toward the nasal fossa or into the ethmoid area This technique is practical only in edentulous patients, and it goes without saying that the cases must be selected very carefully When it is used (see Fig 1) the covering membrane is reflected toward the intact side and is retained *in situ* with the soft palate The advantage of retention of the membrane is that it permits water-tight closure of the surgical field and does away with the former necessity for a palatal prosthesis

5 The cribriform plate was sometimes removed in the original technique It is now removed with considerably greater frequency when it seems an inherent part of the lesion This plate is the last bony barrier between the nasal sinuses and the cranial cavity, but when it is removed, the strong, fibrous dura located between it and the brain tissue acts as a deterrent to the spread of the cancer The plate is always opened when electrocoagulation of the posterior ethmoids is necessary, and when the orbital contents are removed with the maxillary bone Curettement and electrocoagulation is employed when disease has extended to this area

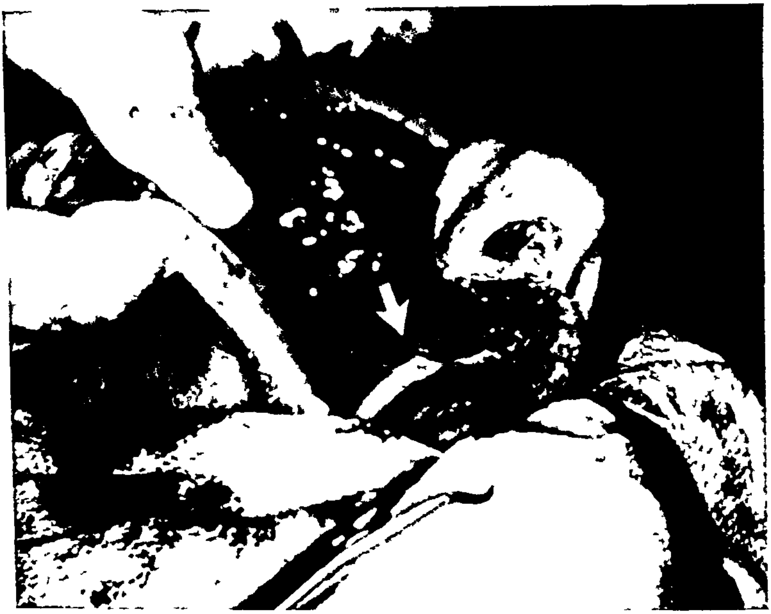

Fig 1 Conservation of mucous membrane over bony palate in radical surgery for carcinoma of the antrum

Whenever the dura is opened, accidentally or deliberately, there is leakage of cerebrospinal fluid, and the cranial cavity is thus laid open to the possible spread of infection from the surgical field The rent in the dura is closed by the application of gelatin foam overlaid by a skin graft, both materials are held in place with the medicated wool packing inserted at the end of the operation

6 The mucous membrane over the septum adjacent to the surgical cavity is removed, even though there is no evidence of its involvement in the malignant process Removal of this membrane facilitates repacking during the postoperative period and makes it much less painful

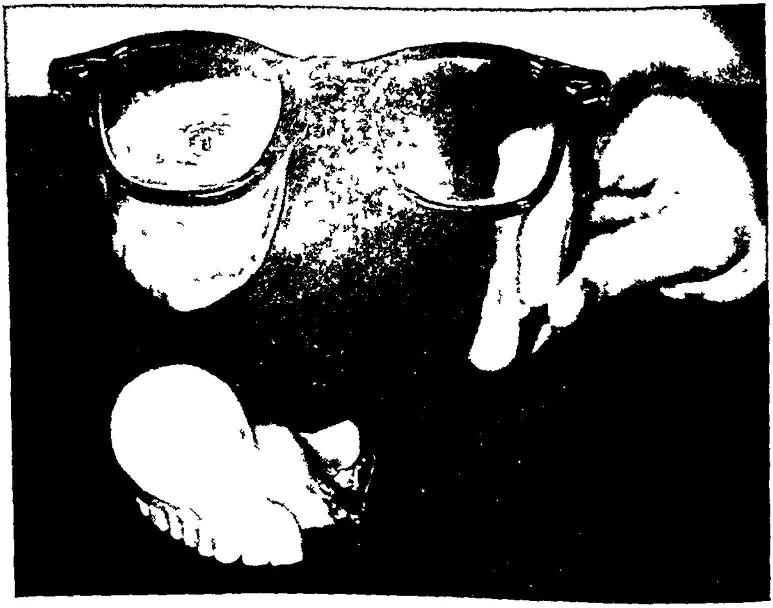

Fig 2 Effective prosthesis for patient who has undergone radical surgery for carcinoma of the antrum (devised and constructed by Mr John H O Donnell, prosthesist)

POSTOPERATIVE IRRADIATION

Irradiation, applied by a competent radiotherapist in maximum doses, is pushed to the limit of tolerance after operation, in every case in which it is not absolutely certain that an entirely adequate margin of disease-free tissue has been removed with the excised specimen

Dr J V. Schlosser, who treated practically all of the cases observed at Charity Hospital of Louisiana at New Orleans, has observed that oxygenation of the tissues to be treated just before they are irradiated appears to potentiate the effect of therapy by sensitizing the tumor cells and thus making the irradiation effects more lethal to them The simultaneous use, in some cases, of oxygen and nitrogen mustard or other chemotherapeutic agents also seems to enhance the effects of irradiation The perfusion techniques, which have given brilliant results in more anatomically favorable areas of the body, have still not been perfected clinically for use in the head and neck, but the outlook is promising

These methods may eventually replace surgery, but their consummation lies in the future. For the present, surgery followed by irradiation is the method which lies at hand, and it should be used promptly and adequately This is a mutilating method, but the mutilation can be quite effectively compensated for by well-made prostheses (see Figs 2, 3), and it is the best method presently available for the salvage of life in a potentially highly lethal disease

ANALYSIS OF CASES

Over the 18-year period ending in December, 1958, I have been able to collect 81 cases of carcinoma of the antrum, 67 from Charity Hospital of Louisiana at New Orleans and the remainder from the Veterans' Administration Hospital and the Eye, Ear, Nose and Throat Hospital in New Orleans Sixty of these cases, which have already been reported,[1] covered the 15-year period ending in June, 1955 The fact that 13 of the second series of 21 cases were observed in 1958 would probably not impress statisticians, but I take considerable encouragement from this recent concentration of cases, and from the fact that 15 of the 21 cases in the second series were referred cases

Forty-three of the 67 patients from the New Orleans Charity Hospital were Negroes, which is in accord with the large Negro component in the hospital population Twenty-nine of the 81 patients in the combined series were female, which is in accord with the generally reported sex incidence The

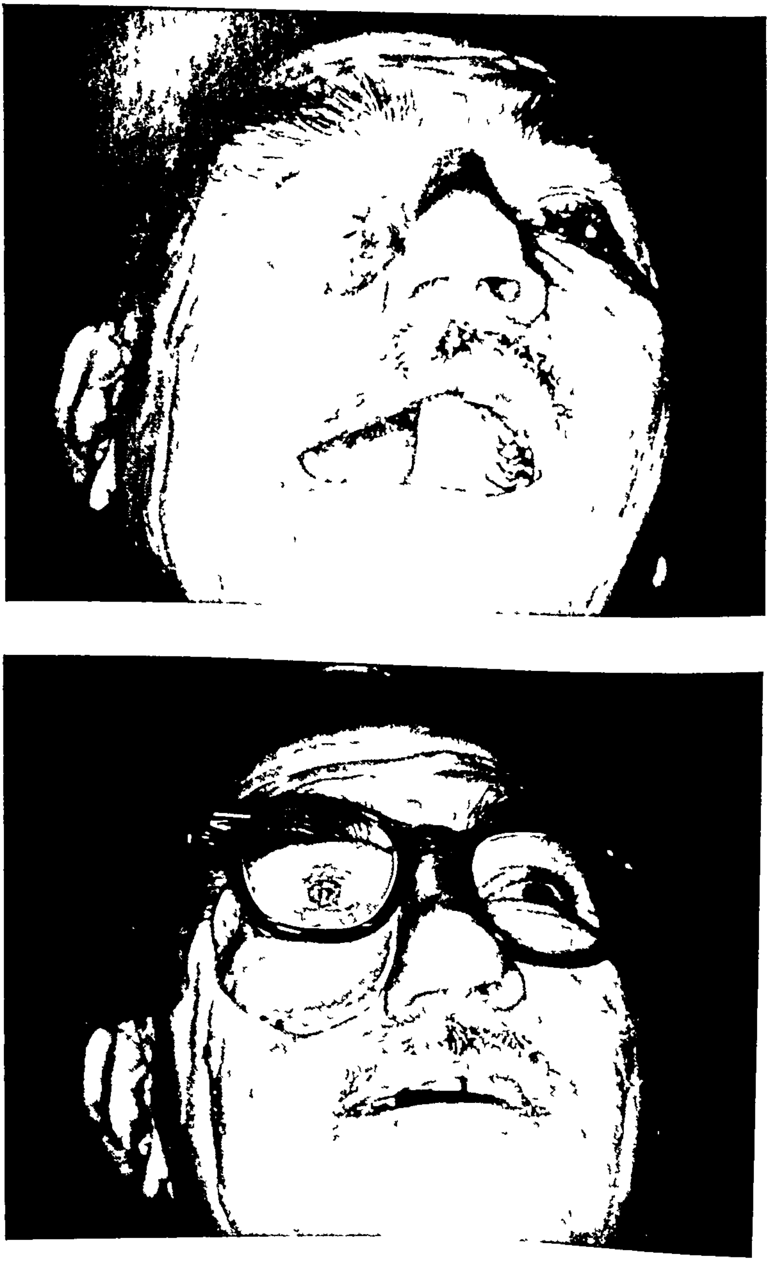

Fig 3 Patient who has undergone radical surgery for carcinoma of the antrum
A Without prosthesis B Wearing prosthesis

age range was from 16 to 77 years, and 58 patients were 50 years of age or older, which again is in accord with general observations

In seven of the 81 cases in this series (see Fig 4), the disease was so far advanced that no curative measures could be considered All of the 27 patients treated by irradiation only were included in the first series of 60 cases reported in 1957,[1] except for one patient in the second series who would not

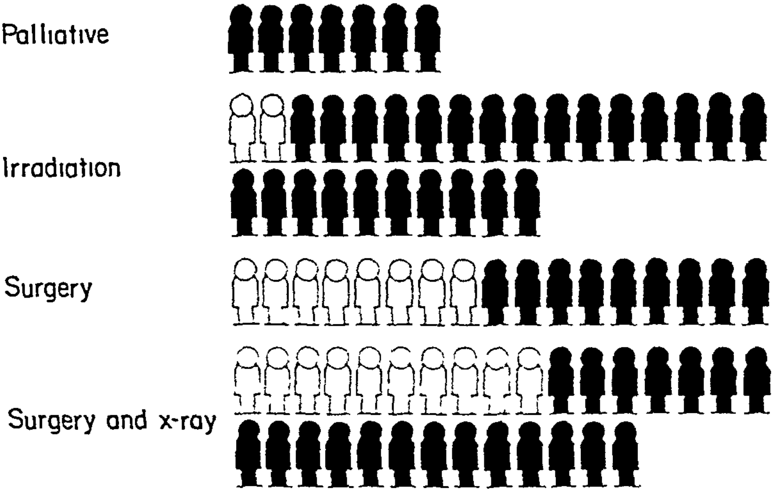

Fig 4 Methods of treatment and mortality in 81 cases of carcinoma of the antrum 1940-1958 Three of the patients still alive after combined surgery and X-ray have recurrent disease

consider surgery Seventeen patients were treated by surgery only, and 30, including most of the patients in the second series, by surgery followed by irradiation In some instances the surgery was not adequate, because of errors of judgment on the part of the surgeon, or because the patients refused to permit the complete operation, or because the disease was too far advanced to accomplish all that was desirable

All but 20 of these 81 patients are dead (see Fig 4), and three of those still living have recurrent disease Of the seven patients treated surgically in the second series who are still alive and well, only three were operated on more than six months ago, and the longest period of survival is two-and-one-half years

On the other hand, all seven of the patients in the first series who were reported to be alive and well in 1957 are still alive and well, one of them for almost 15 years, five between more than five and almost eight years, and the remaining patient for four years and nine months One of these patients, who was operated on in March, 1953, had only a simple maxillectomy then and his eye was not removed Recurrent disease was discovered when he reported for examination in August, 1957 Immediate radical maxillectomy was performed, followed by irradiation, and he is living and well 15 months after this second procedure

Carcinoma of the antrum will probably never be anything but a depressing disease to treat, but, as these cases show, it is not entirely hopeless

SUMMARY

The recorded results of carcinoma of the antrum are discouraging, but they can be improved by a determined effort to make the diagnosis earlier and by a courageous surgical attack upon the disease process Total removal of the sinus is impossible without total removal of the maxillary bone Any surgery not based upon this fundamental concept is not adequate surgery Unless it is entirely certain that the growth has been removed with a margin of disease-free tissue about it, the operation must be followed by irradiation pushed to the limits of tolerance

Certain modifications of the surgical technique which have recently been introduced are described in this communication, and 21 addditional cases are added to the 60 cases reported in 1957[1] None of the 10 surviving patients in the second series have been under observation long enough to permit any statement about end-results, but seven patients in the first series are alive and well for periods varying from four years and nine months to 14 years and nine months

REFERENCE

1 TABB, H G Carcinoma of the Antrum An Analysis of 60 Cases with Special Reference to Primary Surgical Extirpation THE LARYNGOSCOPE, 57 269 341, April, 1957

EARLY DIAGNOSIS AND TREATMENT OF CORROSIVE BURNS OF THE ESOPHAGUS*

EUGENE L. YURICH, M.D.,
Detroit, Mich.

INTRODUCTION

Early in 1957, the author reviewed cases of corrosive burns of the esophagus at this hospital and in the literature. In addition to the variable and controversial methods of therapy, other distressing facts were recognized. These included *1.* Inadequate early diagnosis based mainly on presumptive evidence, *2.* Withholding early therapy because of an inadequate diagnosis, *3.* Institution of therapy without an accurate diagnosis, and *4.* Needlessly long hospital confinement in the majority of instances.

With the advent of Cortisone therapy and its acceptance in the treatment of esophageal burns, it became necessary to revamp our thinking on these matters, and we were prompted to institute earlier and more accurate means of diagnosis.

REVIEW OF THE LITERATURE

Spain and his co-workers[1,2] in 1950, experimented with Cortisone as to its effects on granulation tissue formation in mice. In using high doses of Cortisone, they found that it unquestionably inhibits formation of granulation tissue. It was revealed, however, that Cortisone was effective only in the early stages of involvement and, if instituted later than 48 hours after the tissue injury the result was unsatisfactory. Rosenberg and his associates[3] in 1951, induced lye burns in the esophagi of rabbits, followed by immediate treatment (within 48 hours) with Cortisone. In their series, a marked decrease in fibroplasia occurred with a significantly diminished scar tissue formation. There was a concomitant in-

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crease in secondary infections, mostly intra-thoracic, in the treated cases They repeated their experiments in 1953,[4] administering penicillin in conjunction with the Cortisone There resulted a marked reduction of suppurative infections accompanying the lye burns, although five of 44 rabbits developed spontaneous perforation of the esophagus in the Cortisone-penicillin treated group Weisskopf[5] in 1952, experimented with dogs having induced lye burns of the esophagus, using a terramycin-Cortisone combination therapy In none of the treated cases did a stricture develop, whereas all the controls developed stricture after 35 days He particularly stressed treatment within 48 hours, and antibiotics in combination with the Cortisone

There were questions that arose concerning the value of ACTH either alone or in combination with Cortisone With the former hormone, there is a stimulated production of all the adrenal steroids, including desoxycorticosterone This latter steroid has been reported by Taubenhaus[6] actually to increase fibroplasia

When to do an esophagoscopy imposes a question Some authors[7,8,9,10] feel that early esophagoscopy is dangerous because of the possibility of perforating an already weakened esophageal wall Others[11,12,13] are of the opinion that esophagoscopy should be done within 24 to 48 hours of the time of the burn Still others[14,15] prefer to esophagoscope the patient from the fourth to the seventh day following the ingestion of the caustic agent

PATHOLOGIC CONSIDERATIONS

The usual areas of involvement in the esophagus are the cricopharyngeus, the crossing of the left main bronchus and the cardia The upper esophagus is probably the most frequently involved area, whereas the lower esophagus is usually the most seriously involved, the latter being due to reflex spasm at the cardia [7,16] The extent of injury to the esophagus is dependent upon the agent, duration of contact, concentration and the amount ingested The severity of the burn may be divided into three groups *1* First degree, which involves only the mucosal and submucosal layers. These heal without stricture formation and present little problem in therapy. 2. Second degree, in which the necrosis extends to the muscular wall. In this stage there is initial hyperemia and edema with subsequent ulceration in a few days.[7, 17] By the second week, there is granulation tissue formation, which ultimately converts to fibrous connective tissue and stricture formation. Stricture may develop in three weeks, usually develops within eight weeks, however, on rare occasions it takes several months or even years to present itself.[7, 11] 3. Third degree burns are those with involvement of all layers of the esophagus with associated periesophagitis and mediastinitis. Mortality is high in this group.

Corrosive agents differ as to their effect on the esophagus. Caustic alkalis (*e.g.*, NaOH), produce a liquifactive necrosis, whereas acids (*e.g.*, HCl) produce a coagulation necrosis. Pyloric stenosis is more commonly seen in acid burns, since the alkalis are neutralized by the acidic gastric contents, however, pyloric stenosis can and does occur in alkali burns.[10, 17]

PRESENT STUDY

In the past 18 months (March, 1957, to August, 1958), 37 patients entered the emergency room at Receiving Hospital of Wayne State University with symptoms and signs suggestive of the ingestion of a corrosive agent. Of these, there were 28 (77 per cent) in the age group 10 months to 5 years, and six (16 per cent) in the age group 5 to 10 years. The remaining three (14 years, 26 years and 58 years, respectively) were suicide attempts. The agents taken by mouth were NaOH (27 cases, 75 per cent), lysol, two cases, clinitest tablets, two cases, ammonia (one case), chlorox (one case) and four cases in which the agent was undetermined.

By using early diagnostic pharyngoscopy and esophagoscopy, we were able to narrow the cases of actual burn down to 10 (27 per cent of the suspected 37 patients). Of these ten actual esophageal burns, seven were by NaOH, one by ammonia, one by lysol, and one by an undetermined agent.

Age Distribution

Age	Suspected Burns No	Suspected Burns %	Actual Burns (27%) No	Actual Burns (27%) %
10 months to 5 years	28	77	8	80
6 years to 10 years	6	16		
Over 10 years	3	7	2	20
Total	37	100	10	100

Agents Used

Agent	Suspected Burns No	Suspected Burns %	Actual Burns No	Actual Burns %
NaOH	27	75	7	70
Lysol	2	5	1	10
Clinitest	2	5		
Ammonia	1	2	1	10
Chlorox	1	2		
Undetermined	4	11	1	10
Total	37	100	10	100

DIAGNOSIS

Initially, the diagnosis is presumptive with a history of the ingestion of some corrosive agent. Pain about the mouth, tongue, throat and substernal areas, dysphagia and hoarseness, are symptomatic indications. The finding of burns about the lips, tongue, oropharynx and hypopharynx furnishes additional presumptive evidence of esophageal burns. These findings, however, do not confirm the presence of burns in the esophagus. Contrariwise, an absence of these findings does not obviate the possibility of burns. There are certain cases where the patient arrives in shock with extensive burns of the mouth and pharynx, and/or dyspnea from severe laryngeal burns. In these uncommon cases, the diagnosis becomes quite obvious. It is our belief that early roentgenograms and/or fluoroscopy are not valid either to prove or disprove an esophageal burn. Esophagoscopy is done usually within the first 24 hours. It is always done under general anesthesia, and once the burned area is visualized, the esophagoscope is withdrawn to preclude the possibility of perforating through the burned area.

In the untreated cases of esophageal burn, the patient usually recovers from his initial symptoms after the first week. He then passes into a latent period of from two to four weeks, when he has few or no symptoms. There then develops progressive dysphagia, first for solids and later for semi-solid foods. In uncommon instances, however, the progression may be so insidious as not to give symptoms for months or even years. Often a foreign body lodged in the esophagus may be the first indication of an old stricture. The diagnosis of chronic stricture is made by esophagoscopy and roentgenography, the latter being invaluable in determining the degree, area, tortuosity and length of the stricture.

TREATMENT

A. *Early Treatment:*

Initial treatment is to neutralize the offending agent. For alkalis, acetic acid (1 to 2 per cent), and citrous juices are given in small repeated doses. For acids, olive oil, milk and egg whites are of value. Sodium bicarbonate is not used because of the gas produced with distension and possible induction of vomiting. Gastric tubes are not inserted either for lavage or for feeding purposes, as they add to the original trauma and may tend to incite vomiting with additional corrosive effects to the wall of the esophagus. Since the majority of the caustic agents are neutralized by the gastric contents, it seems illogical to lavage these patients. In the case of acid burns, the argument is not so strong against lavage. All in all, there is much controversy regarding lavage and gastric tubes.[-10 18] Diet is progressed slowly beginning with clear liquids, then pureed foods, and by the end of the week, the patient can ordinarily tolerate semi-solids.

Measures for shock are instituted promptly when indicated, and tracheotomy is carried out if the situation requires it. Antibiotics are given because of the possibility of such complications as periesophagitis, mediastinitis, pulmonary infections, abscess formation and esophageal perforations. Other therapeutic measures include sedatives and analgesics in appropriate dosages.

Steroids are given in relatively large doses, preferably within 24 hours, and always within 48 hours after ingestion of the corrosive agent The average dose for the child in the 1 to 4 year group is 40 to 50 mgm of prednisolone daily in four divided doses The duration of therapy is dependent upon the response to medication as determined by repeat esophagoscopic examinations done at ten day intervals The average duration of therapy in our series was two to three weeks

Eight out of our ten cases of esophageal burns which were treated with steroids responded favorably A typical case is presented

E E, a 3-year old colored male with a history of ingesting "Drano" (NaOH) He arrived in the emergency room in only mild distress from his oral burns Initial examination on July 15, 1957, revealed burns of the lips, tongue, and buccal mucosa Esophagoscopy was done within 12 hours of admission and revealed an area of burn in the mid esophagus at about the area of the crossing of the left bronchus He was placed on penicillin and prednisolone (10 mgm every six hours) Repeat esophagoscopy on July 26, 1957 (11 days after admission) revealed residual eschar in the mid esophagus Steroids were discontinued when a follow up esophagoscopy on August 11, 1957, gave no evidence of residual burn Two esophograms subsequently taken have revealed no tendency toward stricture formation

Of our ten cases of esophageal burns, two developed strictures in spite of what was considered an adequate dose of steroids The first was a short annular stricture of the mid-esophagus which responded well to peroral bougienage The second case is presented

O A, a 2 year old colored male, found by his mother on May 31, 1958, with a can of lye in his hands He was crying, salivating and vomiting On admission to the hospital, there were evident burns of the lips, tongue, buccal mucosa and oropharynx He was moderately dyspneic on admission, but this proceeded to severe dyspnea within 12 hours, and a tracheotomy was performed He was placed on intravenous feedings, analgesics and antibiotics Esophagoscopy within 20 hours of injury revealed severe burns involving the hypopharynx, larynx and cervical esophagus Hydrocortisone (50 mgm every six hours) was instituted On June 11, 1958 (ten days after admission) a repeat esophagoscopy revealed extensive eschar involving the cervical and lower mid esophagus On June 13, 1958, he developed a hemorrhagic gastritis Upper GI series revealed a possible gastric ulcer and Cortisone was discontinued On June 16, 1958, repeat upper GI X-rays were read as negative and Cortisone was re instituted On June 23, 1958, esophagoscopy again revealed persistent eschar in the cervical esophagus and lower mid esophagus On July 8, 1958, there was esophagoscopic evidence of stricture at the lower mid esophagus This was confirmed by fluoroscopy Cortisone was discontinued Gastrostomy was performed on July 18 1958, and after waiting two weeks for healing of the wound, retrograde dilatations were insti tuted using Tucker bougies Up to the present time, he is on such therapy

In cases that are not diagnosed within the 48-hours "grace period," thereby obviating the use of Cortisone, the Salzer technique[19 20] is instituted This consists of daily dilatations with Hurst mercury weighted bougies for three to four weeks and then at gradually decreasing intervals The patient may be forced to continue this treatment for several years, even though feeling well This forces the physician to be very persistent and encouraging

B Late Treatment

1 Blind bougienage—This is mentioned only to be condemned, except in those cases where mercury weighted bougies are used to maintain patency of the lumen

2 Peroral esophagoscopic bougienage[21]—This is excellent for short, single, annular strictures, but not of use in patients with multiple, long or tortuous strictures

3 Peroral bougienage over a string[22]—The patient swallows a silk thread and, when anchored securely in the gut, a fenestrated olive-tipped bougie is passed over the thread using the latter as a guide

4 Peroral bougienage over piano wire—This has been used very successfully in our clinic, using the Eder-Puestow dilator set This consists of a piano wire with a flexible tip which can be passed easily through the esophagus The wire acts as a guide for the staff and olive-tipped bougies which are passed over it The advantage of this over string is that the passage of the wire and the dilatation may be carried out at the same clinic visit

5 Retrograde bougienage[23]—This technique necessitates a gastrostomy, but it is very effective and is the least dangerous method of dilatation It is especially useful in children and uncooperative adults Treatment is long and tedious and may be followed by mercury weighted bougie dilatation

6 Surgical repair of the esophagus—The two methods mainly used are esophagogastrostomy and esophagojejunostomy It is generally felt, that if at all possible, dilatation is preferential to surgery There are some, however, who value surgery very highly in certain cases [13,16,24]

COMMENT

It is quite evident that a great deal of controversy remains regarding the diagnosis and treatment of esophageal burns In stressing the use of early esophagoscopy, in no instance were there any untoward effects in our series Since ulceration and sloughing do not usually take place until "after a few days,"[7,17] it appears logical to assume that the esophagus would resist more trauma initially than it would, for example, from the fourth to the seventh day In instituting treatment on a presumptive basis alone, there is imposed upon the patient unnecessary hospital stay, financial obligations and medical therapy

The average duration of stay for the suspected burn cases with negative esophagoscopic examinations was two or three days as compared to two or three weeks for the treated cases In addition, it presents a needless worry to the patient and family regarding the possibility of stricture later in life

The use of Cortisone is a rather recent adjunct in the treatment of esophageal burns, but it is rapidly becoming a more widely acceptable early form of therapy It is not, however, the entire answer to the problem, as is evidenced by the two failures in our series even with apparently adequate dosages There is the possibility, however, that the Cortisone did decrease in degree the amount of stricture, but this would be difficult to prove We are convinced that Cortisone and its allied steroid compounds are of definite value in our armamentarium against the formation of esophageal strictures

Our ultimate goal should be in the realm of prophylaxis by the prevention of such accidents through adequate education and enforced legislation Until such time arrives, we shall be forced to search for new and better methods of therapy

SUMMARY

1 Treatment of corrosive burns of the esophagus is controversial

2 Early esophagoscopy within 24 to 48 hours is stressed as a means of adequate and accurate early diagnosis

3 The theories and experimental data supporting Cortisone therapy are presented

4 Pathologic considerations are outlined

5 Early and late treatment of esophageal burns are outlined with particular reference to Cortisone therapy

6 A series of 37 suspected cases are reported, of which ten had actual burns by esophagoscopic examination The burned cases were placed on Cortisone therapy Eight patients responded favorably, whereas two developed strictures in spite of treatment

7 A successful case with Cortisone therapy is presented

8 A failure in Cortisone therapy is presented

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THE FENESTRATION OPERATION A PERSPECTIVE IN TIME †

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This report is a continuation of a long-term study[1-9] (begun in January, 1945) of the results of tests of hearing conducted on all of the patients upon whom the fenestration operation has been performed by one of us (T E W) at McMillan Hospital (Department of Otolaryngology, Washington University School of Medicine) It deals with the first 818 patients upon whom the fenestration operation was performed We here compare with respect to hearing for spondaic words measured three months post-operatively, a large number of heretofore unreported cases, with the cases that have been described in the earlier reports To make these comparisons, the 332 cases dealt with in the earlier reports are treated as a single group (Group I), and the 486 new cases are divided into two groups of similar size representing approximately equal intervals of time (Groups II and III)

In addition to the comparisons among Groups I, II, and III, the earlier data, from Group I, will be used to evaluate long-term effects with respect to the stability of *1* operative results, in terms of hearing level for spondaic words, *2* hearing level for spondaic words in unoperated, otosclerotic ears, and *3* speech discrimination scores for both fenestrated and unoperated ears of otosclerotic patients

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*From Central Institute for the Deaf and Hofheimer Audiology Laboratory of the Department of Otolaryngology of Washington University This research was partially supported by a grant (B-243) to Central Institute for the Deaf from the National Institute of Neurological Diseases and Blindness

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The measure of hearing used is the threshold for spondaic words as determined with recorded speech materials[10] The discrimination scores were obtained with the Rush Hughes recordings of PB Auditory Tests 9, 10, 11 and 12[11]

Final hearing level‡ is used because in this context it is a more logical measure of the outcome of the fenestration operation than gain[6] A discussion of this point is included in Appendix A

RESULTS AND DISCUSSION

COMPARISON AMONG GROUPS

The purpose of the comparison among the three chronological groups is to determine whether there has been a significant improvement from group to group in mean hearing level measured three months after the fenestration operation and, if so, to describe this improvement

TABLE I DESCRIPTION OF GROUPS I, II, AND III

	Group I	Group II	Group III
Dates	Jan , 1945, to July, 1949	Sept , 1949, to May, 1953	May, 1953 to July, 1956
Case Numbers	1-332	333 567	568 818
Sample Size	199	232	227
Mean Age	33 6	34 2	35 0
Variability in Age (S D *)	9 41	8 76	9 78
Age Range	7 64	13 64	15 61

*S D = Standard Deviation

The three groups are described in Table I Some cases were dropped from the analysis for the following reasons Group I, 132 cases in which a cartilagenous stopple was used, and one case in which speech audiometry was not used, Group II, three cases for which there were no post-operative tests of hearing, and Group III, 14 cases in which a stapes mobilization procedure preceded the fenestration operation, nine cases in which there have been no post-operative tests of hearing, and one case in which speech audiometry was not used

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‡Final Hearing Level is the exact equivalent of Residual Hearing Loss used by Davis and Walsh[6] The new term follows the recent recommendation of Davis Parrack and Hoople[12] to substitute hearing level' for hearing loss when referring to audiometric measurements of the status of hearing

The results of the comparison among groups with respect to mean hearing level measured three months after the fenestration operation are presented graphically in Fig 1 In this figure, the time scale (abscissa) is in years, and the mean hearing level for each group is plotted at the midpoint

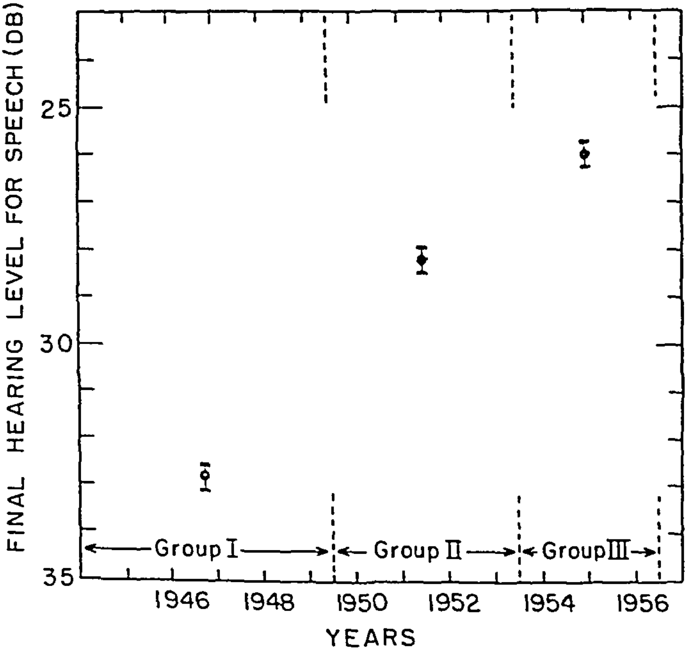

Fig 1 Adjusted mean final hearing level for speech (spondaic words) as a function of chronological group (I II and III)

of the time interval during which the fenestration operations within each group were performed

Figure 1 shows that the mean hearing level measured three months after the fenestration operation has improved by 3 5 db from Group I to Group II (from 32 7 to 29 2 db), and by 3 1 db from Group II to Group III (from 29 2 to 26 1 db) These changes are statistically significant beyond the 1 per cent level of confidence This improvement is probably the

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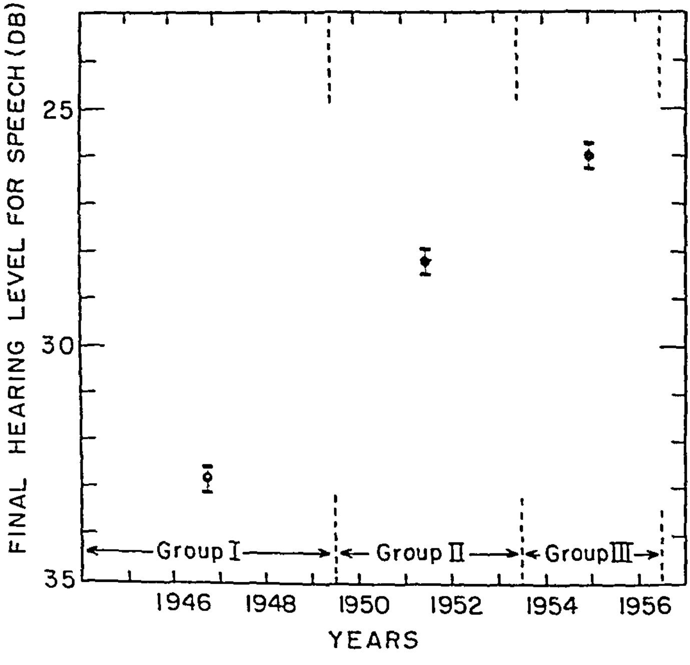

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Two features of the means presented in Fig 1 are important, first, these means have been adjusted by the techniques of analysis of covariance to take into account the statistically significant difference between the groups with respect to preoperative hearing levels (Appendix A, Table A-1) This procedure is described in Appendix A Second, *no cases were excluded from this analysis on the basis of the outcome of the fenestration operation,* so that the improvement from group to group of approximately 3 db represents the average of *all* cases, including the failures

TABLE II

Percentage and Cumulative Percentages of Each Group Having the Indicated Post Operative (3 Months) Hearing Level for Spondaic Words

Hearing Level (db)	Group I Per cent	Group I Cumulative per cent	Group II Per cent	Group II Cumulative per cent	Group III Per cent	Group III Cumulative per cent
20 db or better	3 0		12 1		28 2	
21 25	24 6	27 6	29 3	41 4	32 6	60 8
26 30	30 7	58 3	29 3	70 7	18 1	78 9
31 35	14 1	72 4	12 5	83 2	11 9	90 8
36 40	10 0	82 4	6 5	89 7	4 0	94 8
40 db or worse	10 6	93 0	7 3	97 0	4 0	98 8
No gain	7 0		3 0		1 2	

In order to determine where the improvement from group to group, with respect to hearing level measured three months after the fenestration operation, has been most pronounced, the percentage of each group attaining final hearing levels of 20 db or better, 21-35, 26-30, 31-35, 36-40, and 41 db or worse, as well as those in which there was no gain, was tabulated The results of these tabulations are presented in Table II In addition to the percentage of cases in each group with the specified hearing level, the percentage of each group with hearing level equal to or better than the indicated hearing level is presented in the column headed "cumulative per cent"

Davis and Walsh[b] report that 84.7 per cent of their cases (from Group I) had hearing levels better than 41 db three months after the fenestration operation. For the 199 cases called Group I in this report, 82.4 per cent had levels better than 41 db (see cumulative per cent for the 36-40 db interval of Group I in Table II). This slight discrepancy arises because the first five cases (No. 1 to No. 5), included in Group I, were not included in the sample of cases reported by Davis and Walsh.

Comparing the three groups with respect to the cumulative percentage of each group having final hearing levels better than 41 db (Table II), we see that the percentage of cases reaching this final hearing level increases from 82.4 per cent of Group I to 89.7 per cent of Group II to 94.8 per cent of Group III. When we compare the cumulative percentages of each group having final hearing levels better than 35, 30 and 25 db, the improvement from group to group is even more striking.

A comparison of the groups with respect to the percentage of cases that reached the theoretical "limit of improvement,"[c] a final hearing level of 20 db or better, shows that while only 3 per cent of Group I had final hearing levels of this magnitude, 12.1 per cent of Group II and 28.2 per cent of Group III received the maximum benefit from the fenestration operation.

At the other end of the hearing level continuum, there is a large decrease in the percentage of cases having final hearing levels worse than 35 db. 27.6 per cent of Group I compared to 16.8 per cent of Group II and only 9.2 per cent of Group III. The percentage of cases showing no gain as the result of the fenestration operation decreased from 7.0 per cent of Group I to 3.0 per cent of Group II and 1.2 per cent of Group III.

The hearing level measured three months after the fenestration operation is the only variable dealt with here. Even so, on the basis of the distributions of these hearing levels, it seems reasonable to attribute the increased percentage of cases having hearing levels better than 25 db to refinements in surgical techniques, and the decreased percentage of cases having final hearing levels worse than 35 db to refinements in selection of cases and to better surgery also

CLOSURES

In an earlier report in this series, Davis, Walsh, and Eldert[7] observed that closures occurred in 22 of the 151 cases (14 6 per cent) from Group I in which there had been at least 10 db of improvement in hearing as the result of the fenestration operation They suspected closure if the patient lost 10 db or more of hearing between the first (three months) and a subsequent post-operative test of hearing They considered the closure to be confirmed when the patient gave a negative response to the fistula test In every one of these cases, closure was confirmed by the end of the first year after the fenestration operation The median post-operative interval at which closure was confirmed was 7 5 months, and the range of time over which closures were confirmed was from one to 12 months The time-course for closure that they describe is consistent with their assumption that closure is related to the healing process

As part of the present study, we tabulated the number of closures in Groups II and III, using the criteria listed by Davis, Walsh, and Eldert[7] There were six closures among the 211 cases (2 8 per cent) in Group II in which there had been at least 10 db improvement in hearing In Group III there were seven closures among the 215 cases (3 3 per cent) in which there had been 10 db of improvement The six closures in Group II were confirmed at the following post-operative intervals 6, 8, 9, 9, 10 and 11 months For Group III the seven closures were confirmed at 6, 6, 6, 7, 7, 12 and 18(?) months post-operatively In the case of the closure confirmed at 18 months, it is impossible to specify the time at which closure was complete, because the patient did not return for a check-up between three and 18 months after the operation

When we compare the three groups with respect to the incidence of closure, we see that it drops sharply from 14 6 per cent in Group I to about 3 per cent in Groups II and III

This decrease in the incidence of closures is almost certainly the result of modifications in surgical procedure

The number of closures in Groups II and III, six and seven respectively, is too small to permit statistical comparisons of the time-course for closure, but since testing at six months was introduced into the follow-up routine, it should be mentioned that only four of the 13 closures in Groups II and III were confirmed by the end of six months after surgery The timing of the second post-operative test between 7 5 and nine months after surgery might maximize the detection of closures at the second post-operative interval

STABILITY OF HEARING IN FENESTRATED EARS

Davis, Walsh, and Eldert[7] report that among successfully fenestrated ears (129 cases from Group I) a mean loss (decrement) in hearing, a threshold shift, of 2 8 db occurs during the first year after the operation They attribute this rise in threshold to the normal healing process It should be noted that the threshold shift and the closure both have been identified with normal healing, and both take place during the first year after surgery

The purpose of this portion of the study was to determine whether hearing level in successfully fenestrated ears remains stable beyond the first year after the operation

Stability of Hearing in Group I

We used the data for the 43 patients in Group I whose hearing level three months after the operation was 35 db or better and who had returned for follow-up tests at the following post-operative intervals three months, one year, three years, and seven years The mean age for this sample from Group I, Subgroup I-A, at the time of the operation was 34 4 years

The mean hearing level at each post-operative interval is plotted in Fig 2 for Subgroup I-A Statistical analysis (see Appendix B, Table B-1) of these data indicate that the loss of hearing for spondaic words that occurs during the first year is statistically significant beyond the 1 per cent level of confidence The mean hearing levels at three and seven

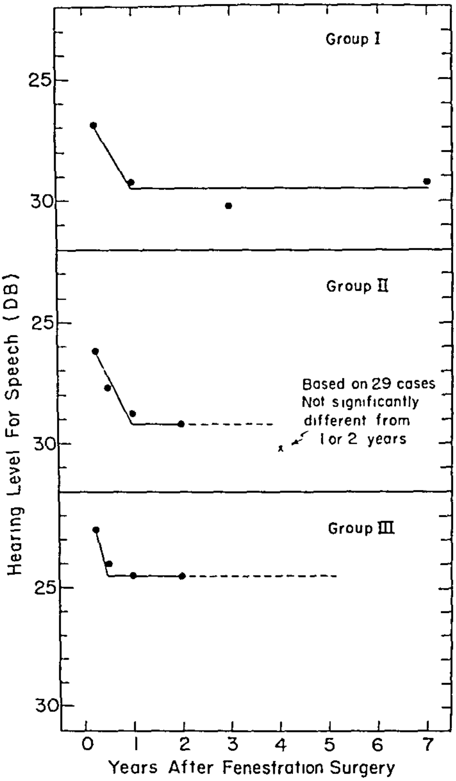

Fig 2 Mean hearing level for speech (spondaic words) as a function of time after surgery for 43 successfully fenestrated ears from Group I (Subgroup I-A) The line represents an interpretation of the statistical analysis and is not fitted to the data

Fig 3 Mean hearing level for speech (spondaic words) as a function of time after surgery for 63 successfully fenestrated ears from Group II (Subgroup II-A) The point at four years after surgery represents 29 cases from Subgroup II-A (Subgroup II-B) The line represents an interpretation of the statistical analysis and is not fitted to the data

Fig 4 Mean hearing level for speech (spondaic words) as a function of time after surgery for 42 successfully fenestrated ears from Group III (Subgroup III-A) The line represents an interpretation of the statistical analysis and is not fitted to the data

years, however, are not significantly different from the mean hearing level measured at the end of the first year after the operation The solid line in Fig 2 has been drawn to show that hearing got worse during the first year after the operation but remained constant thereafter The threshold shift observed during the first year for Subgroup I-A of 2 5 db is only slightly smaller than that reported by Davis, Walsh, and Eldert[7] for a different and larger sample from Group I

It is possible that the procedure by which the 43 cases in Subgroup I-A were selected has produced a spurious result To make sure that the result is correct, we retested the hypothesis that *hearing in successfully fenestrated ears remains stable beyond the first year after the operation* To accomplish this retest, a new sample was selected from Group I, Subgroup I-B, that included all patients (113) whose hearing level three months after the operation was 35 db or better, and who had appeared for follow-up tests of hearing two years or more after the operation, as well as at three months and one year The median post-operative interval at which the last test of hearing was obtained was 6 94 years Closures were excluded from Subgroup I-B

For Subgroup I-B the mean hearing level three months after the operation was 27 0 db and one year after the operation it was 29 4 db, a loss of 2 4 db The mean hearing level for the last post-operative test of hearing (6 94 years post-operatively) was 29 0 db The results of the statistical analysis of these data (see Appendix B, Table B-2) confirm our hypothesis that hearing does not get worse after the first year after the operation This result confirms the conclusion of Davis, Walsh, and Eldert[7] that the decrement observed over the first year after the operation is related to the healing process

Threshold Shift and Unreliability

The results presented up to this point have dealt only with mean hearing levels at several post-operative intervals Results stated in this form are of little use in evaluating individual cases In order to present the information about the long-term stability of hearing in successfully fenestrated ears in a form more amenable to direct comparison with individual cases, we tabulated the amount and direction of threshold shift between one year after the operation and the last measure of hearing level (6 94 years) for the 113 cases in Subgroup I-B These results are presented in Table III In 64 7 per cent of the cases either there was no threshold shift between one year after the operation and the last test of hearing, or the hearing level at the later date was better than it had been one year after the operation. The most improvement was 11 db and the largest loss was 15 db.

Thurlow *et al.*[5] have pointed out that there is random fluctuation involved in the measurement of the threshold for speech (spondaic words). If we use their estimates of the magnitude of this random fluctuation (standard error of measurement or *measure of unreliability*), we would expect

TABLE III

Shift in Hearing Level Between Tests of Hearing One Year After Fenestration Operation and the Last Available Test of Hearing*

Threshold Shift	Number	Per cent	Cumulative Per cent
9-11 db gain	1	.9	
7-8 db gain	5	4.4	5.3
5-6 db gain	11	13.3	18.6
3-4 db gain	16	14.2	32.8
1-2 db gain	23	20.4	53.2
0 db (no shift)	13	11.5	64.7
1-2 db loss	12	10.6	75.3
3-4 db loss	11	9.7	85.0
5-6 db loss	7	6.2	91.2
7-8 db loss	4	3.5	94.7
9-15 db loss	6	5.3	100.0
	113		

*The median post-operative interval for the last available test was 6.94 years.

about 33 per cent of the thresholds to have shifted more than 4.2 db, regardless of direction of shift. From Table III we can see that 38 out of the 113 thresholds, or 33.6 per cent, shifted more than 4.2 db. In addition, only 5 per cent of the thresholds would be expected to shift more than 8.4 db. Actually six of the 113, or 5.3 per cent, shifted more than 8.2 db. We conclude, on this basis, that the distribution of thresholds in Table III does not differ from what is predicted solely on the basis of random fluctuations involved in measuring the threshold for speech (spondaic words).

Analysis of data from Group I has shown, therefore, that there is a statistically significant loss of hearing during the first year after a successful fenestration operation, but that there is no change in hearing level after the first year The distribution of threshold shifts between 1 0 and 6 91 years (median post-operative interval for the last test of hearing) after the operation is not different from a theoretical distribution based on the random fluctuations involved in measuring hearing level for speech (spondaic words)

Stability of Hearing, Groups II and III

Data were selected from Groups II and III to compare these groups to Group I with respect to the long-term stability of hearing in fenestrated ears The data from Groups II and III do not cover as long a post-operative interval as those from Group I since these are chronological groups The data for Groups II and III are more detailed for the first year after the operation, however, because a check-up six months after the operation was introduced into the schedule at the end of the period during which the cases in Group I were operated In addition to comparing the groups with respect to long-term stability of hearing, we were able to determine whether the loss of hearing following fenestration took as long to stabilize in Groups II and III as it had taken in Group I

Sixty-three patients from Group II, whose hearing level three months after the operation was 35 db or better returned for follow-up tests of hearing at six months, one year, and two years in addition to those at three months Of these 63 patients, 29 had been operated early enough in the series to have returned for follow-up tests of hearing four years after the operation The mean hearing levels of the 63 patients, Subgroup II-A, are plotted in Fig 3 as a function of time after the operation The mean hearing level for Subgroup II-B, 29 cases tested four years after the operation, is plotted at four years after the operation The solid line in Fig 3 is drawn to show that, as in the case of Group I, hearing gets worse during the first year after the operation but remains stable thereafter Statistical analyses of the data for these subgroups (see Appendix B, Table B-3 and Table B-4) gave the same results that were obtained for Subgroup I-A (Appendix B, Table B-1)

In Group III, there were 42 patients whose hearing level three months after the operation was 35 db or better, and who had returned for follow-up tests of hearing at six months, one year, and two years, as well as at three months after the operation The mean levels for these 42 patients, Subgroup III-A, as a function of time after the operation, are plotted in Fig 4, in which the solid line has been drawn to show that hearing level gets worse only during the first six months after the operation and then remains stable thereafter The statistical analysis of these data (see Appendix B, Table B-5) indicates that the mean hearing level at six months after the operation is significantly worse than at three months after the operation, beyond the 1 per cent level of confidence, but that there are no differences among mean hearing levels for six months, one year, and two years

Summary Stability of Hearing

In all three of these chronological groups the hearing level in fenestrated ears was found to be stable after an initial, statistically significant, loss of hearing This threshold shift was 2 5 db for fenestrated ears in Groups I and II, but was only 1 4 db in Group III For Groups I and II the shift was not complete until the end of the first year after the operation

Improvement in the results of fenestration surgery in terms of final hearing level can also be demonstrated in terms of a decrease in the shift for the worse that immediately follows fenestration surgery and in terms of the time course of this shift The threshold shift decreases from 2 5 db in Groups I and II to 1 4 db in Group III

The only change in technique between the periods covered by Groups II and III was the introduction of Neo-Cortef ointment (Upjohn) in packs in the cavity and over the flap in June, 1953

STABILITY OF HEARING IN UNOPERATED OTOSCLEROTIC EARS

The purpose of this portion of the study is to determine the rate at which hearing loss increases in unoperated, otosclerotic ears over long periods of time

Data were available on 34 patients from Group I (Subgroup I-C), on whom only one ear had been operated These patients had returned for follow-up tests on both their fenestrated and their unoperated ears one, three, and seven years, as well as at three months after the operation

The mean hearing levels at the various intervals after the operation are plotted in Fig 5 According to the statistical analysis of these data, the only statistically significant shift in threshold took place between the third and the seventh year after the operation The solid line drawn in Fig 5 was fitted to the points by a least squares technique and this line, with a slope of 1 db per year, fits the data very well Because the rate at which hearing level rises is so slow, 1 db per year, the statistical analysis could not detect the shift over only one or two years, but a linear trend is clearly demonstrated by these data as a whole

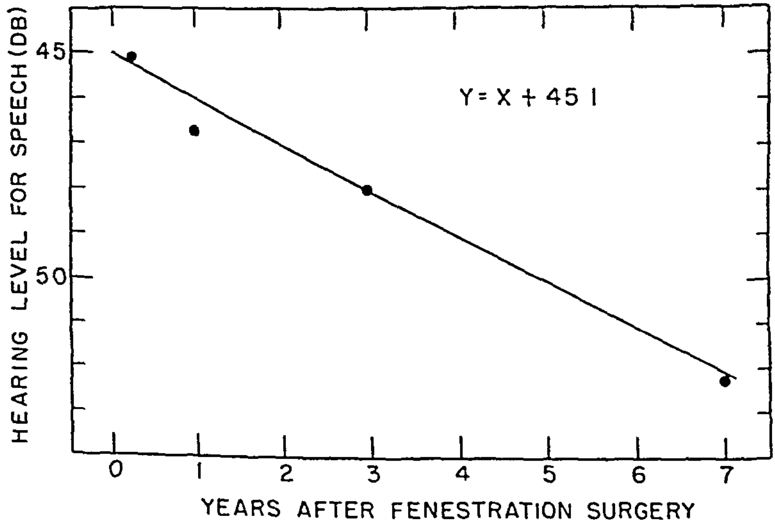

Fig 5 Mean hearing level for speech (spondaic words) as a function of time after surgery was performed on the contralateral ear for 34 unoperated otosclerotic ears from Group I (Subgroup I-C) The line has been fitted to the data by the least squares technique

The comparison of the stability of hearing level in fenestrated and unoperated otosclerotic ears reveals that while hearing level does not change appreciably in fenestrated ears after the operation, except for the slight shift during the first year after operation, the unoperated otosclerotic ears very slowly become less sensitive, at a rate of about 1 db per year.

STABILITY OF SPEECH DISCRIMINATION SCORES IN FENESTRATED AND UNOPERATED OTOSCLEROTIC EARS

The purpose of this part of the study is to determine whether the speech discrimination scores for fenestrated and unoperated otosclerotic ears remain stable over long periods of time

There were 37 patients in Group I with one fenestrated and one unoperated otosclerotic ear In this group of patients the hearing level in the fenestrated ear three months after the operation was 35 db or better They had returned for follow-up tests of hearing on both ears at three months, three years, and seven years The mean age of these patients at the time the operation was performed was 33 7 years Speech discrimination scores were measured with the Rush Hughes recordings of the PB word lists These recordings were played back to the patient at sound pressure levels of at least 100 db (re 0 0002 dynes/cm^2)

The mean speech discrimination scores for the fenestrated and for the unoperated ears of these patients are plotted in Fig 6 as a function of time after the operation A single line has been drawn in Fig 6 to show that no statistically significant differences were found between the mean speech discrimination scores for the fenestrated and for the unoperated otosclerotic ears at any interval after the operation (see Appendix D, Table D-1) Both ears, however, show a decrease in speech discrimination scores between the third and seventh year after the operation that is statistically significant at the 1 per cent level of confidence

It has been claimed that the fenestration operation will prevent the development of secondary nerve deafness Because the maximum discrimination score can be assumed to measure the integrity of the cochlea,[1] we are able to evaluate this claim for a seven-year period of time The result, no difference between the fenestrated and the unoperated ear, three or seven years after surgery, fails to support this claim.

The observed decrease in speech discrimination scores of 5.3 per cent between the third and seventh year after the operation can be explained in either of two ways. First, it is possible that this decrease is a result of the continuing otosclerotic process, and that this process is not impeded by the fenestration operation. On the other hand, it is possible that a comparable loss of speech discrimination will occur in a similar group of normal ears between the ages of 36.7 and 40.7 years as a result of aging. In order to determine which of these explanations is the most valid, it would be necessary to measure the speech discrimination of a group of people with normal ears at comparable age intervals. If the people with normal ears show a decrease in speech discrimination

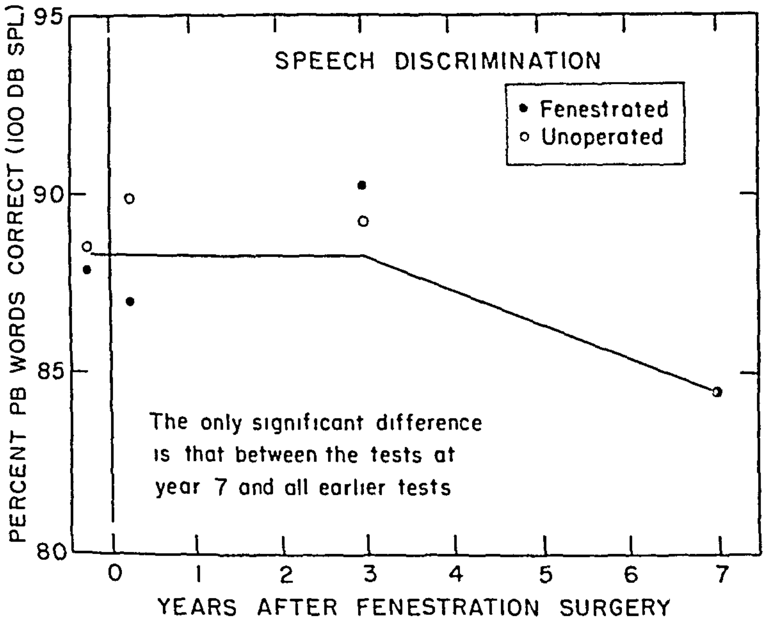

Fig. 6. Speech discrimination in both fenestrated and unoperated ears as a function of time after surgery for 37 patients from Group I (Subgroup I-D). The line represents an interpretation of the statistical analysis and is not fitted to the data.

score of 5 per cent between the ages of 36.7 and 40.7 years, we could assume that the decrease observed here was the result of normal aging and not the result of the otosclerosis.

SUMMARY

Follow-up tests of hearing have been conducted over periods from three months to nine years on 818 patients upon whom the fenestration operation has been performed. These patients are divided into three chronological groups. The first group, Group I, includes all cases reported earlier (1951), and Groups II and III include 486 cases heretofore unreported. The three groups are compared with respect to, *1* hearing level for spondaic words measured three months after the fenestration operation, *2* closure of the fenestra, and *3* long-term stability of hearing for spondaic words. In addition, the long-term stability of hearing level for spondaic words in unoperated otosclerotic ears is assessed, and long-term stability of speech discrimination scores in both fenestrated and unoperated otosclerotic ears is studied.

The average hearing level for spondaic words, measured three months after the fenestration operation, is 3.5 db better in Group II than in Group I, and 3.1 db better still in Group III than in Group II. The percentage of patients having final hearing levels of 20 db or better was only 3.0 per cent in Group I, but increased to 12.1 per cent in Group II and 28.2 per cent in Group III. The percentage of patients with final hearing levels worse than 35 db decreased from 27.6 per cent in Group I to 16.8 per cent in Group II to only 9.2 per cent in Group III.

Closure occurred in 14.6 per cent of the cases in Group I, but in only 2.8 per cent of Group II and 3.3 per cent of Group III.

Hearing level for spondaic words in fenestrated ears remained stable after an initial loss. In Groups I and II this early threshold shift was 2.5 db and took place during the first year after surgery. In Group III the initial loss of sensitivity was only 1.4 db and was complete at the end of six months.

Hearing in unoperated otosclerotic ears got worse at a rate of about 1 db per year, when time was counted from the date at which the fenestration operation was performed on the opposite ear

Speech discrimination scores were the same in 37 unoperated otosclerotic ears as they were in the corresponding fenestrated ears The speech discrimination scores did *not* decrease more rapidly in the unoperated than in the fenestrated ear Between the third and seventh postoperative year, speech discrimination scores for both ears decreased by about 5 per cent

In general, after a fenestration operation we may expect the final hearing level in the fenestrated ear to increase slightly in the first six months after the operation and to remain stable thereafter In the unoperated otosclerotic ear, on the other hand, hearing for spondaic words will get worse at the rate of about 1 db each year after the time of the operation The fenestration operation does not affect the slight fall in speech discrimination scores which occurs over a period of several years

APPENDIX A

The first step in the comparison among the three groups (I, II, and III) was to perform an analysis of variance on the pre-operative hearing levels The analysis of variance design used was a simple, single classification analysis of variance[13] The assumption of homogeneity of variance involved in this analysis was tested (Bartlett's test) and found to be tenable

The results of the analysis of variance performed on the pre-operative hearing levels are presented in Table A-1 The significant "among groups" effect indicates that the three groups were different with respect to pre-operative hearing level This result indicates that the appropriate manner of comparing the groups with respect to the outcome of the fenestration operation is the technique of analysis of covariance This technique enables us to "match" the groups with respect to pre-operative hearing levels

The analysis of covariance technique involves a complicated set of assumptions that must be tested empirically as part of the computational procedure These assumptions deal with the correlation between pre-operative and final hearing level in the present case These assumptions can be summarized by saying that it is necessary to show that there is a significant correlation between pre-operative and final hearing level, and that this correlation is essentially the same in every group The assumptions were tested and found to be tenable

TABLE A 1

Results of Analysis of Variance Comparison Among Groups I, II, and III With Respect to Pre Operative Hearing Level

Source of Variation	df	Mean Square	F
Among Groups I, II, and III	3	201 65	4 33*
Error	655	46 59	

*Significant beyond the 1 per cent level of confidence

TABLE A-2

Results of Analysis of Covariance Comparison Among Groups I, II, and III with Respect to Final Hearing Level

Source of Variation	df	Adjusted Mean Square	F
Among Groups I, II, and III	3	2,314 23	23 97*
Error	654	96 55	

*Significant beyond the 1 per cent level of confidence

The results of the analysis of covariance performed on the final hearing levels are presented in Table A-2 These results indicate that there was, on the average, an improvement of 3 25 db between successive groups, and that this improvement was highly significant The degree of correlation between pre-operative and final hearing level is 34 and it, too, is highly significant

FINAL HEARING LEVEL VS GAIN

In applied statistics the analysis of covariance is always used instead of a difference (between pre-operative and final hearing level) score, because the conditions that must be satisfied before gain (difference) can be used legitimately are very difficult to fulfill in a non-laboratory context. This comment is appropriate, since the issue of final hearing level vs. gain is relevant to otological surgery. Although Davis and Walsh[7] have already discussed this issue in terms of the limits of improvement in hearing following fenestration surgery, it still remains open. We shall discuss the issue from the point of view of the logic relating to statistics and measurement, but we shall not ignore the point of view presented by Davis and Walsh.

Any measure of "gain" is suspect in statistics because its use assumes that the amount of gain is independent of the initial measure (pre-operative hearing level). This assumption cannot be met in the case of fenestration surgery for two reasons: first, there is a real limit on how efficiently an ear can function once the ossicular chain has been interrupted. Davis and Walsh[7] point out that because of this limitation, final hearing levels cannot be much better than 20 db. In addition, the fenestration operation can only remedy the conductive component of a hearing loss. Since the maximum conductive component of a hearing loss is limited to about 60 db (because of bone conduction), the maximum possible improvement is about 40 db (60 db – 20 db = 40 db).[7]

Whenever a large number of cases is distributed within limits such as those described by Davis and Walsh[7] (discussed above), we must expect a significant correlation to appear. In the present study, the correlation between pre-operative and final hearing level of .34 was used to facilitate the comparison among groups with respect to final hearing level, but the correlation is not large enough to use in predicting the outcome of any individual operations, since only 11.4 per cent of the variability in final hearing level can be accounted for by the correlation between pre-operative and final hearing level. This leaves us with Final Hearing Level as the measure to use in evaluating the improvement in hearing following a fenestration operation. *The best prediction that a surgeon can make is that each case of purely conductive hearing loss will reach the mean final hearing level for his previous patients.*

The analysis of covariance technique involves a complicated set of assumptions that must be tested empirically as part of the computational procedure. These assumptions deal with the correlation between pre-operative and final hearing level in the present case. These assumptions can be summarized by saying that it is necessary to show that there is a significant correlation between pre-operative and final hearing level, and that this correlation is essentially the same in every group. The assumptions were tested and found to be tenable.

TABLE A 1

Results of Analysis of Variance Comparison Among Groups I, II, and III With Respect to Pre-Operative Hearing Level

Source of Variation	df	Mean Square	F
Among Groups I, II, and III	3	201.65	4.33*
Error	655	46.59	

*Significant beyond the 1 per cent level of confidence

TABLE A 2

Results of Analysis of Covariance Comparison Among Groups I, II, and III with Respect to Final Hearing Level

Source of Variation	df	Adjusted Mean Square	F
Among Groups I, II, and III	3	2,314.23	23.97*
Error	654	96.55	

*Significant beyond the 1 per cent level of confidence

The results of the analysis of covariance performed on the final hearing levels are presented in Table A-2. These results indicate that there was, on the average, an improvement of 3.25 db between successive groups, and that this improvement was highly significant. The degree of correlation between pre-operative and final hearing level is .34 and it, too, is highly significant.

FINAL HEARING LEVEL VS GAIN

In applied statistics the analysis of covariance is always used instead of a difference (between pre-operative and final hearing level) score, because the conditions that must be satisfied before gain (difference) can be used legitimately

TABLE B-5

Results of Analysis of Variance Stability of Hearing in Fenestrated Ears
(Subgroup III A, N = 42)

Source of Variation	df	Mean Square	F
Patients	41	68.62	
Years after surgery	3	31.45	4.90*
Error	123	6.42	

*Significant beyond the 1 per cent level of confidence

ference was found "among years after surgery" for each of the five subgroups. The Newman-Keuls sequential range test[14] was used to determine the significance of the differences among the various individual means. The outcome of the comparisons among the individual mean hearing levels as a function of time after fenestration surgery is described in the text for each subgroup.

APPENDIX C

The analysis of variance design used to test for the stability of hearing in the unoperated otosclerotic ears was again a simple two-way classification analysis of variance in which patients were assumed to be a random variable.[13] A statistically significant difference among "years after surgery" was found. The sequential range test[14] indicated that the only significant difference among the mean hearing levels for years after surgery was between years three and seven. The line drawn in Fig. 5 was fitted by least squares. The fit is good enough to allow us to assume that the change over one or two years is too small to be detected.

TABLE C-1

Results of Analysis of Variance Stability of Hearing in Unoperated Ears
(Subgroup I C, N = 34)

Source of Variation	df	Mean Square	F
Patients	33	225.13	
Years after surgery†	3	322.30	11.02*
Error	99	29.26	

*Significant beyond the 1 per cent level of confidence
†Surgery performed on contralateral ear

APPENDIX B

The analysis of variance design used to test the stability of hearing in fenestrated ears as a function of years after the fenestration operation, was a simple two-way classification design in which patients were assumed to be a random variable.[13] The same design was used on all five subgroups. As shown in Tables B-1 to B-5, a statistically significant dif-

TABLE B-1

Results of Analysis of Variance. Stability of Hearing in Fenestrated Ears (Subgroup I-A, N = 43)

Source of Variation	df	Mean Square	F
Patients	42	109.75	
Years after surgery	3	89.43	6.45*
Error	126	13.86	

*Significant beyond the 1 per cent level of confidence

TABLE B-2

Results of Analysis of Variance. Stability of Hearing in Fenestrated Ears (Subgroup I-B, N = 113)

Source of Variation	df	Mean Square	F
Patients	112	74.98	
Years after surgery	2	193.18	14.24*
Error	224	13.57	

*Significant beyond the 1 per cent level of confidence

TABLE B-3

Results of Analysis of Variance. Stability of Hearing in Fenestrated Ears (Subgroup II A, N = 63)

Source of Variation	df	Mean Square	F
Patients	62	209.44	
Years after surgery	3	116.12	3.76*
Error	186	30.92	

*Significant beyond the 1 per cent level of confidence

TABLE B-4

Results of Analysis of Variance. Stability of Hearing in Fenestrated Ears (Subgroup II B, N = 29)

Source of Variation	df	Mean Square	F
Patients	28	150.59	
Years after surgery	4	63.08	6.08*
Error	112	10.37	

*Significant beyond the 1 per cent level of confidence

5 Thurlow, W R Silverman, S R, Davis H, and Walsh T E Further Statistical Study of Auditory Tests in Relation to the Fenestration Operation The Laryngoscope, 59 113 129, 1949

6 Davis H and Walsh T E The Limits of Improvement of Hearing Following the Fenestration Operation The Laryngoscope, 60 273-295, 1950

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13 Walker, H, and Lev J "Statistical Inference," pp 348-425, Henry Holt & Co, New York, 1953

14 Duncan, D B Multiple Range and Multiple F Tests *Biometrics*, 11 1 42, 1955

NEW RESEARCH LABORATORY

The Elbyrne G Gill Eye and Ear Foundation announces the establishment of a Research Laboratory in conjunction with the Eye Bank and Sight Conservation Society of Virginia under the direction of Miss Jean Swartz, M S in chemistry The laboratory is prepared to make the dye test for Toxoplasmosis

APPENDIX D

The analysis of variance design used to test for difference between the operated and unoperated ears as a function of time after surgery was a three-way classification analysis of variance in which patients were assumed to be a random variable[13] The percentage scores on the PB words were converted to the arcsin of the square root of the percentage to meet the assumption of homogeneity of variance,[13]

TABLE D 1

Results of Analysis of Variance Stability of Speech Discrimination Scores for Fenestrated and Unoperated Ears (Subgroup I-D, N = 37)

Source of Variation	df	Mean Square	F
Patients (P)	36	2065	
Fenestrated and unoperated ears (E)	1	0467	98
Interaction of E and P	36	0477	
Years after surgery (Y)	3	4107	7 66*
Interaction of Y and P	108	0536	
Interaction of E and Y	3	0402	1 93
Interaction of E, Y, and P	108	0208	

*Significant beyond the 1 per cent level of confidence

and the analysis was performed on these transformed scores The failure of the interaction between years and operated vs unoperated ears is the most important result in Table D-1 The interpretation of this result is discussed in the text The sequential range test[14] was used to compare the mean PB scores at the different post-operative intervals, and only the difference between years three and seven was found to be significant

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2 Falconer, G A, and Davis, H The Intelligibility of Connected Discourse as a Test for the "Threshold for Speech" The Laryngoscope, 57 581 595, 1947

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Interaction of E and Y	3	0402	1 93
Interaction of E, Y, and P	108	0208	

*Significant beyond the 1 per cent level of confidence

and the analysis was performed on these transformed scores The failure of the interaction between years and operated vs unoperated ears is the most important result in Table D-1 The interpretation of this result is discussed in the text The sequential range test[14] was used to compare the mean PB scores at the different post-operative intervals, and only the difference between years three and seven was found to be significant

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compare the incidence of bone and joint changes for this material with those of previous observations,[1,2] second, to compare the bony changes with those described by Nager and Ruedi,[4] and Ogilvie and Hall[5] in the small piece of bone consisting of three layers of the otic capsule removed at the time of fenestration from the roof of the ampullary end of the horizontal canal, each of these reports described bony changes in 18 per cent of the specimens, these percentages are in close agreement to those Nylen,[6] who studied sections of temporal bones from otosclerotics and reported an incidence of alterations in this area for 15 per cent of the specimens, third, to review the structural differences between the bone of the ossicles and that of the capsule in terms of the pathology of the lesions, a feature common to each is the presence of calcified cartilaginous rests Typical otosclerotic foci within the ossicles are known to be a rarity,[3,7] and probably occur in only the most "malignant" form of the disease

TABLE I

Changes Within the Incus Head of the Malleus and Malleo Incudal Joint Surfaces Classified According to Degrees of Severity (Percentage Values—209 Specimens)

	Malleus Head		Incus		Diffuse Bony Changes (%)		Joint Surfaces	
	No	%	No	%	Malleus	Incus	No	%
Group I	(79)	37.8	(98)	46.9	10.1	7.1	104	49.7
Group II	(110)	52.6	(95)	45.5	20.9	13.7	84	40.2
Group III ..	(16)	7.7	(13)	6.2	56.3	46.2	17	8.1
Group IV	(4)	1.9	(3)	1.4	75.0	53.4	4	2.0

The present report is to be considered as a preliminary study, since a subsequent histochemical analysis of bone of the ossicles and otic capsule may yield more pertinent information

RESULTS

A classification (see Table I) of changes in bone of ossicles and in joint surfaces was made on the following basis Group I—the bone showed no changes, or only slight alterations such as early blue mantles and/or beginning canalization, the joint surfaces were without changes or revealed evidence

FURTHER STUDIES ON THE PATHOLOGY OF OSSICLES IN OTOSCLEROSIS*

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and
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A large collection of sectioned and stained preparations of the incus and head of the malleus has been made available for study as a result of fenestration surgery. The bone and joint changes in similar material have been described by Lempert and Wolf.[1,2] Other observations on ossicles in place in sectioned temporal bones, showing otosclerotic foci with and without ankylosis of the footplate of the stapes, have been reported (Covell[3]). From studies up to the present time it has become apparent that:

1. Alignment of the ossicular chain is frequently altered and individual ossicles of the chain may become distorted in shape;

2. Changes occur within the articular cartilages, fibrocartilaginous pad and capsules of the joints of an atrophic and degenerative nature;

3. The bone, chiefly in the region of the articular surface, usually shows irregularity in pattern, large canals, altered vascularity, blue mantles, fibrous marrow, lipping, and an occasional hyperostosis may occur; and,

4. Similar bony changes without joint pathology may occur in the absence of ankylosis, but in the presence of an otosclerotic focus within the otic capsule.

The purpose of the present studies is three-fold: first, to

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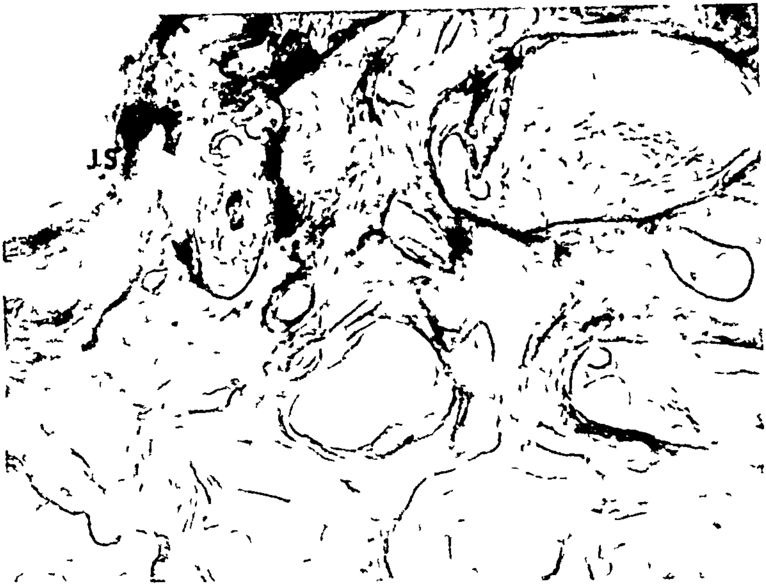

Fig 2 An advanced type of change in the incus classified as Group IV There is a marked osteoporosis with some fibrous marrow and erosion of the joint surface (JS) which showed ankylosis at one point The greatest irregularity in the bony structure aside from extreme canalization occurred near the joint surface 72X

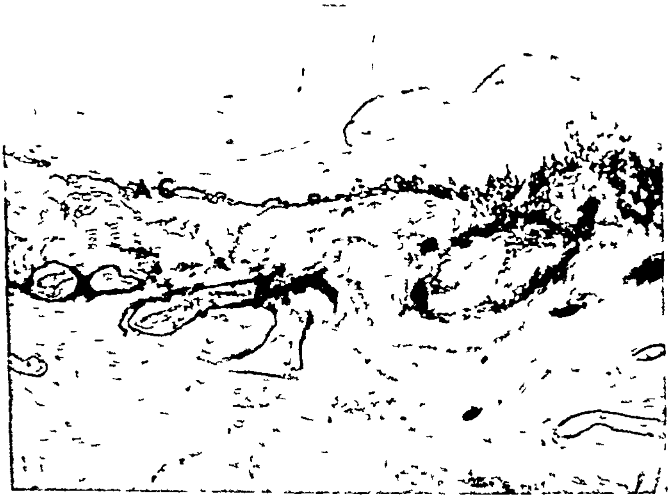

Fig 3 Joint surface of the malleus showing erosion through the more basal layers of the articular cartilage (AC)

of a beginning necrosis of articular cartilage in the area adjacent to bone of the ossicle Group II—alterations in the bone were considered to be of mild to moderate degree (see Fig 1), these consisted of prominent blue mantles, beginning irregularity in formation of new bone, large canals, some containing loose fibrous connective tissue and blood vessels, the joint changes were considered to be thinning and necrosis

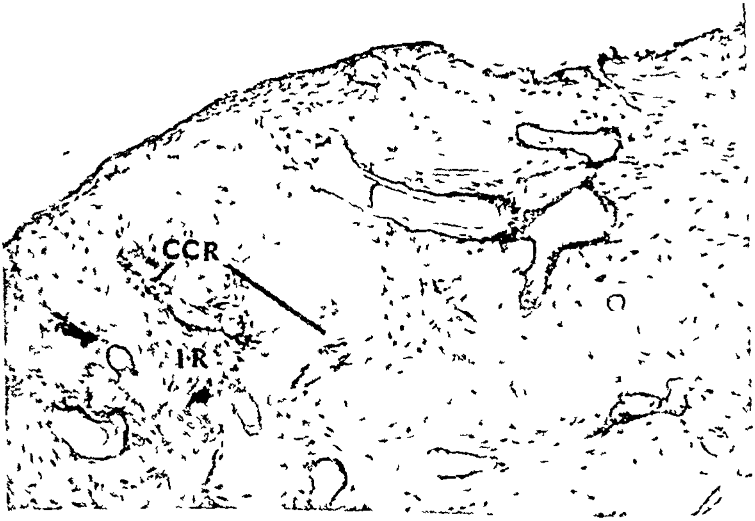

Fig 1 An early change in bone of the head of the malleus showing some increase in diameter of canals that contain loose fibrous connective tissue and vessels The bony wall of each canal has a narrow margin of deeply stained material This particular specimen was classified in Group II CCR calcified cartilaginous rests IR irregularity in bony pattern 72X

of the basal portion of the articular cartilage, and occasionally irregular areas of overgrowth of cartilage in this layer Group III—revealed moderate to severe changes such as marked irregularity in pattern of bone, remodeling of Haversian systems, prominent canalization and sometimes large fibrous-filled cavities, the articular cartilages showed erosion (see Fig 3), calcification of the fibro-cartilaginous pad, and usually lipping of bone at the periphery of the joint Group IV—changes (see Fig 2) were extremely marked with replacement of old bone by fibrous connective tissue with poor vascularity, marked osteoporosis or an extreme amount of an were similar in percentage values to those for the malleus In other words, 30 per cent of Group I were negative for findings, while 70 per cent definitely showed early changes The percentages for Group III and IV were somewhat less, although comparable to those for the malleus

Approximately 38 per cent of the preparations showed changes in the ossicles of a diffuse type These were more numerous for the malleus than incus in the ratio of about 2 1

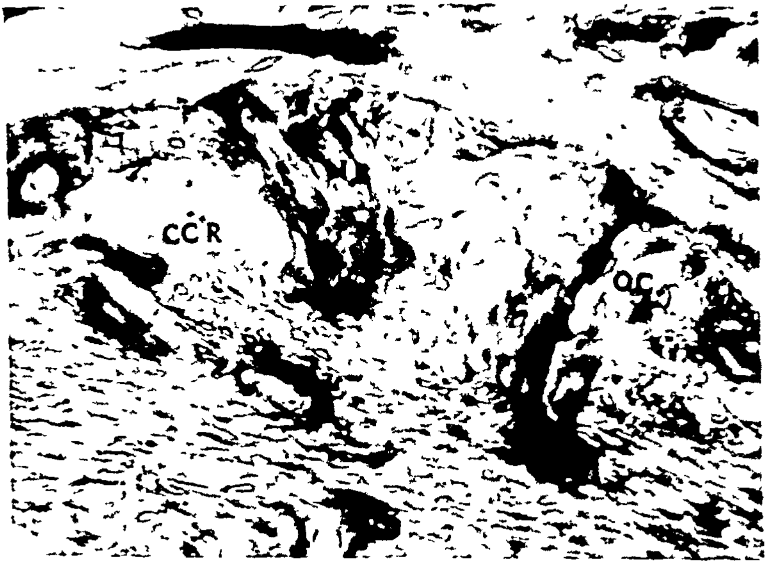

Fig 4 Disintegration of calcified cartilaginous rests with an attempt to fill in the cavity with new lamellar-type bone The osteocytes to the right are particularly irregular in size and shape and their processes shrunken and distorted CCR calcified cartilaginous rests NB new bone formation OC osteocytes 240X

The changes in malleo-incudal articular cartilages, also classified according to four groups, were approximately 49 7 per cent, Group I, 40 2 per cent, Group II, 8 1 per cent, Group III, and 2 per cent, Group IV The changes in the joint surfaces were considered to be less marked than those in the ossicles in 20 per cent of the specimens, and of approximately the same value for changes more marked in the joints than those in the ossicles The grouping of the joint changes and those for the bone were usually in close agreement When a irregularly patterned bone, the joint cartilages were markedly eroded (see Fig 2), with presence of some bony ankylosis

At the time of making observations it was found that the bone of each ossicle nearest the joint surface revealed the more pronounced changes, however diffuse bony alterations were sometimes present The percentages for diffuse involvement on the basis of classification into Groups are shown in Table I Approximately 10 per cent of Group I showed diffuse changes in head and neck of the malleus and 7 per cent in the body and short process of the incus, the bone of the long process being less often involved The percentage of specimens showing diffuse changes usually increased with the severity of the lesions, and were greater for the malleus than for the incus Seventy-five per cent of Group IV revealed a diffuse type of change in the malleus, and 53 4 per cent in the incus

In Table I are shown the total number of observations for the malleus head and whole incus with percentage values listed for each of the four groups

Groups I and II were further subdivided into two groups each, depending upon the severity of the findings Approximately 38 per cent of the preparations of the head of the malleus were Group I findings Included under Group I are the specimens for which no bone or joint pathology was discernible This amounted to 14, or 6 7 per cent of the 209 preparations of the head and neck of the malleus, and 25, or approximately 12 per cent of the incus specimens The articular cartilages of the joints revealed no specific alterations in 31, or 14 8 per cent of the preparations About 53 per cent of the malleolar findings fell into Group II Twenty-two per cent of these were more marked in appearance than the remaining 78 per cent There was 7 7 per cent of the 209 specimens in Group III, and 1 9 per cent in Group IV

The results for incus studies were in about the same proportion to each malleus group, except there was a higher percentage showing Group I changes and a lower percentage showing Group II changes The subdivisions for each group were similar in percentage values to those for the malleus In other words, 30 per cent of Group I were negative for findings, while 70 per cent definitely showed early changes The percentages for Group III and IV were somewhat less, although comparable to those for the malleus

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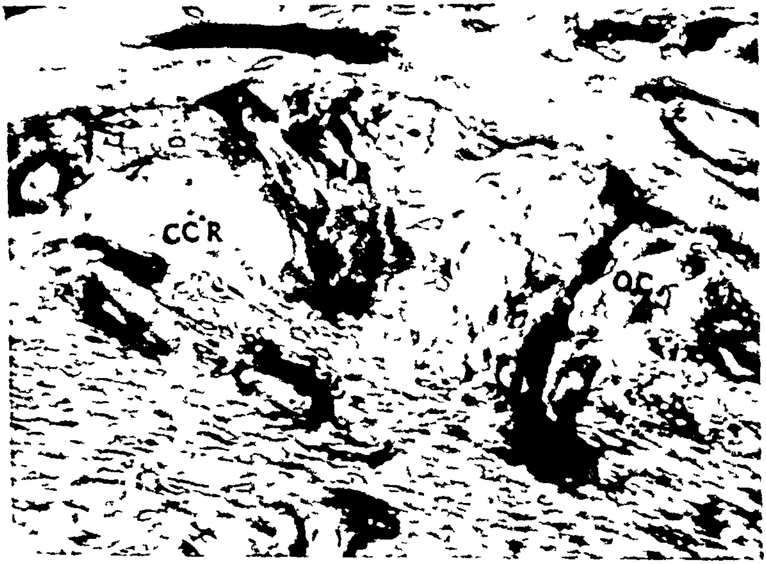

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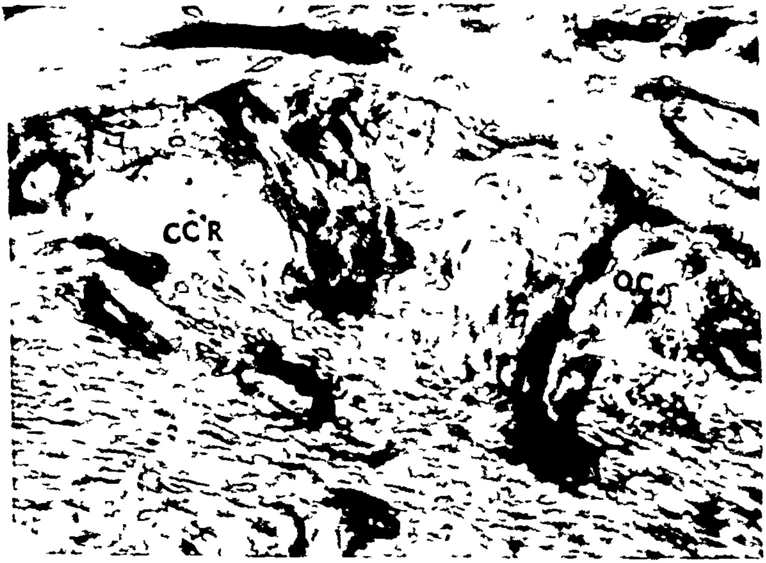

Fig. 4. Disintegration of calcified cartilaginous rests with an attempt to fill in the cavity with new lamellar-type bone. The osteocytes to the right are particularly irregular in size and shape and their processes shrunken and distorted. CCR, calcified cartilaginous rests; NB, new bone formation; OC, osteocytes. 240X.

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There remains only a few points to contribute to the histological detail of the alterations previously described[1,2,3,4,5] Figure 4 represents a degenerative change within the calcified cartilaginous rests and an attempt to fill in the cavity with new bone These calcified cartilaginous cells are apparently incapable of proliferation and formation of new cartilage Vascular channels may also encroach upon such cavities, and they may become filled with a dense fibrous connective tissue The distorted osteocytes (see Fig 4) and the accompanying irregularity of pattern of bone produce a peculiar appearance This has been described as "seedy" or "peppery"

DISCUSSION

The present studies are in agreement with the histopathological findings previously described, and are similar to the changes in some of the specimens described by Ogilvie and Hall[5] for the small piece of bone removed from the ampullary end of the horizontal canal The presence of canalization in the bone nearest the joints is one of the earliest changes This is preceded and accompanied by the appearance of blue mantles, which are to be regarded as areas of absorption and deposition of bone These and subsequent alterations occasionally become diffuse through most of the malleus and incus The changes in the blood vessels and the resulting pathology in vascularity of the bone of these ossicles have been amply described by Lempert and Wolff[1,2] The variations in the appearance of bone suggest an interference with nutrition and an abnormal metabolism

The vascularity of the enchondral bone of the capsule and of the ossicles may be inadequate under certain conditions, because the proper nutrition of bone has been found to be dependent upon diffusion of substances from capillaries placed within "a fraction of a millimeter of each bone cell." The distorted and atrophic processes of osteocytes frequently seen in the vicinity of ossicular lesions would tend to support this view. It is undoubtedly the inherent low vitality and metabolism of enchondral bone that makes it particularly susceptible to any changes that might result from a diminished vascularity. According to Nager and Nager the malleus and incus each contain a large cavity which is occupied by a "vascular convolute." The principal blood supply to these ossicles is by the "ossicular artery" which is a branch of the anterior tympanic artery. It divides into malleolar and incudal branches. While they described anastomoses between branches of the arteries, the existence of end arteries in the finer ramifications of the vessels cannot be refuted. The irregularity present in the cement lines of the laminated bone in some Haversian systems indicates periods of arrested growth. The present material was not stained by methods to demonstrate fibrils, but there is no doubt that woven and laminated areas would appear similar to those described for the otic capsule. In the ossicles the mosaic pattern of the otosclerotic focus in the capsule is not predominate. There is, however, a tendency for irregularity of pattern and "seedy" appearance to be more pronounced in some specimens than others. The sparsity of osteoclasts in areas in which absorption of bone is prominent is not surprising, if we are to share the views of Harris and Ham regarding their significance.

The bone that comprises the ossicles usually does not contain as many calcified cartilagenous rests as the enchondral layer of the otic capsule. Except for the compactness of this bone and its relatively poor vascularity the occurrence of calcified cartilaginous rests within it serve to distinguish it from most other skeletal bone. Any significance of the interglobular spaces and their contents in pathologic changes is uncertain, although they become encroached upon by disease and may disappear entirely. It is possible that present day histochemical and autoradiographic techniques might throw some light upon their importance.

The changes in the joint surfaces observed for ossicles from otosclerotics can be explained on the basis of *1* altered nutrition due to the vascular changes in the region of the joint surfaces The first evidence of such is a necrosis of the basal layer of the articular cartilage which is comprised of large cartilage cells and clear matrix Invariably the bone adjoining these areas showing this change exhibits the typical vascular alterations already described The final result produces a marked thinning of the articular cartilage and irregularities in its thickness and composition in other areas Occasionally the basal layer of the articular cartilage may undergo a compensatory overgrowth Cavities filled with calcifying cartilage may be seen to encroach on the bone and later undergo necrosis *2* The joints between malleus and incus and incus and stapes reflect the ankylosis of the footplate of the stapes, by the appearances of calcium placques, uneven wearing of the articular disc and finally erosion of the articular cartilage with malposition of the joint surfaces, and even some degree of locking if not ankylosis of the malleo-incudal joint Distortion of the joint surfaces may result in some displacement without ankylosis of the stapes footplate as shown in results reported by one of us[3]

SUMMARY

A classification of bony changes into four groups for 209 preparations, consisting of head and neck of malleus and the incus made available by fenestration surgery, revealed the following *1* approximately 38 per cent of malleus specimens showed none or only very slight to moderate changes, 7 7 per cent were considered as moderate to severe and 1 9 per cent as extreme, *2* approximately 47 per cent of incus specimens were of Group I, 45 5 per cent, Group II, 6 2 per cent, Group III and 1 4 per cent, Group IV The stained sections of the ossicles were further grouped according to diffuse or localized bony changes with the result that the more marked and severe changes were more often accompanied by diffuse bony changes

Degenerative changes within the articular cartilages, erosion and even ankylosis of the malleo-incudal joint were found to occur in 50 3 per cent, while the remaining 49 7 per cent showed none or very slight changes

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ANNOUNCEMENT

The Annual Spring Meeting of the Alumni Association of the New York Eye and Ear Infirmary will take place April 20-23, 1959, at the Infirmary

Symposia will be offered on Headache, Allergy and Immunology in Otolaryngology, Diagnosis and Treatment of Laryngeal Conditions; Hearing Rehabilitation, and Rhinoplasty In addition, there will be a closed circuit television demonstration of Head and Neck Surgery

Additional information may be obtained by writing to Dr John R Finley, Secretary, Alumni Association, 218 Second Avenue, New York 3, N Y

LOUDNESS RECRUITMENT AND VERTIGO[*][†]

WALTER ALEXANDER, M D ,

Winnipeg, Canada

HISTORICAL

Few sensations resulting from stimulation of special sense organs reach the conscious level from threshold intensities of stimulation The ear is no exception, it rarely listens to sound of faint intensity, but is most frequently used to make intelligible the meaning of sounds which normally occur at 40 to 60 dbs above threshold With the use of tuning forks, and for many years following the advent of the audiometer, the acuity of hearing was measured at minimal audibility, and little regard was paid to the ability of the patient to understand sound or speech at intensities well above threshold, indeed, at those levels where ordinary conversation is usually maintained

Fowler[6] of New York described the "binaural loudness balance test" in 1936 He determined and recorded the phenomenon that some people had a difference in loudness intensity necessary for binaural loudness balance at different intensities, *i e*, a poor ear might hear loud sounds disproportionately well as compared with faint sounds On the other hand, in some patients there was a constant difference or no difference in intensity necessary to balance, binaurally, the loudness at all frequencies Fowler's findings, in essence, differentiated the normal and/or conductively deaf ear from those with perceptive hearing losses

The binaural loudness balance test (to be described) did not engender great enthusiasm among otologists for some years, however, in the late 1940's Fowler's concepts were revived by British and European otologists, and in more re-

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[†] Reprinted from Prooceedings of the Canadian Otolaryngological Society 1957

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cent years considerable enthusiasm for the test, with some modifications, has been in evidence in the American literature

METHOD OF TESTING FOR RECRUITMENT

The patient wears a set of earphones which are connected to a single audiometer with arrangements for independent adjustments of the intensities The frequency of the sound is the same in each earphone, and the examiner may switch the sound alternately from the left to the right ear, or vice versa

The threshold of hearing for either ear is determined conventionally and recorded on the audiograms The diagrams in Fig 1 represent the audiograms of a patient with conduction deafness, a normal hearing patient, and one with perception deafness

The audiometer is a popular one, with two channels recording the hearing loss in the right or left ear independently or simultaneously The binaural loudness balance test may be used at any frequency from 250 to 4000, but most frequently is recorded at the 1000 cycle frequency A sound of given intensity, say 30 dbs, is delivered to the better ear, and the intensity of sound delivered to the poorer hearing ear is increased until the patient states that the intensity of the sound is equally loud in the two ears The differential is recorded as indicated in the lower diagrams in Fig. 1 The sound intensity is then increased to 40 or 50 or 60 dbs in the better ear, and the intensity in the second channel delivering sound to the poorer ear is increased until the patient remarks that the sound is equally loud in either ear, the corresponding points of equal loudness are then recorded on the graph

In a case of unilateral conductive deafness, the differential of sound intensities necessary to balance the sensation of loudness in either ear will be shifted the same number of decibels as is evident at threshold In normal hearing ears, of course, the sound intensity necessary to create a sensation of equal loudness will always be of an equal number of decibels intensity in either ear On the other hand, in some types of perceptive hearing loss, the differential which is found at

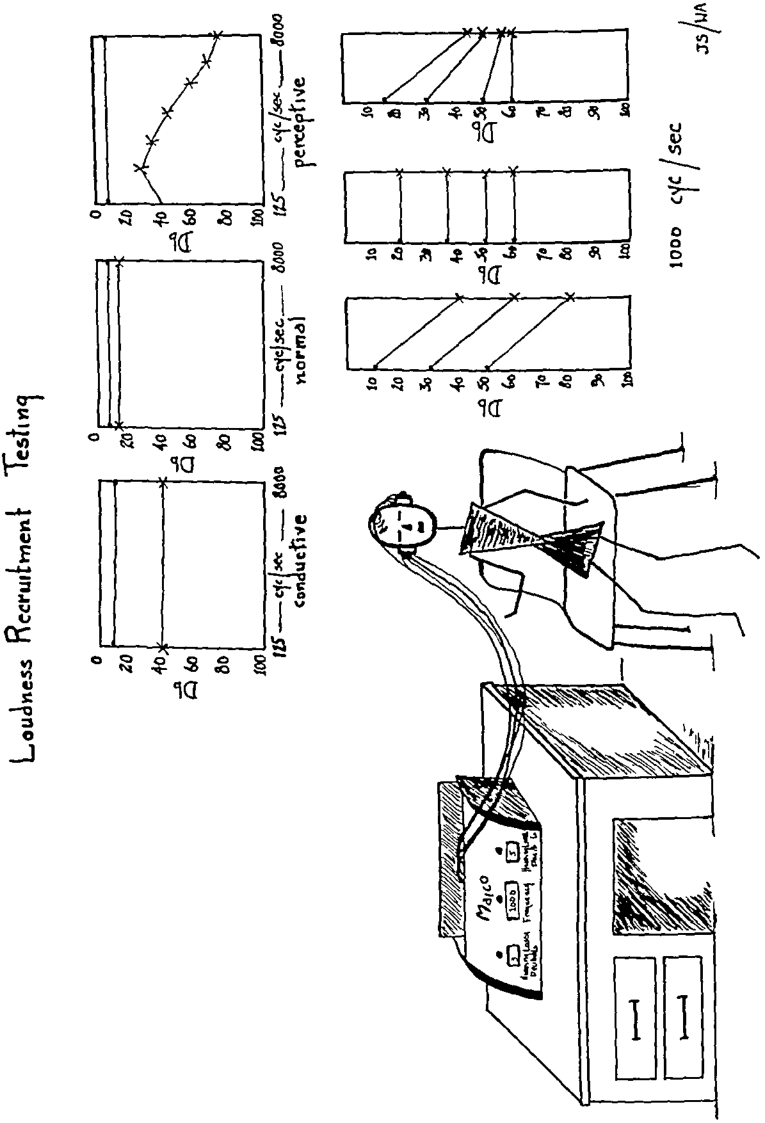
Loudness Recruitment Testing
Db
125 — cyc/sec — 8000
conductive
normal
perceptive
1000 cyc/sec
JS/HA
Maico
Frequency

Fig 1

threshold will gradually subside until at high intensities the sound pressures necessary to create a sensation of equal loudness in the two ears will parallel one another, even though a marked discrepancy may be present at threshold intensities In some types of perceptive deafness, the deafness of the affected ear at threshold disappears at the higher intensities and this, in essence, constitutes the phenomenon of loudness recruitment as evidenced with the binaural loudness balance test of Fowler

Because the physiological phenomenon of "adaptation" may influence the recorded end-point in recruitment testing, it is necessary to instruct the patient explicitly with regard to the end-point of balanced hearing sensation and thereafter carry out the test with dispatch

Fowler's test for binaural loudness balance is easily and simply carried out, however, some modifications have been proposed which give quite comparable results Such tests are known as the "bifrequency loudness balance test," the "de Bruines-Altes test," etc

DIFFERENCE LIMEN TESTING

Luscher[19] states "The difference limen for tone intensity variations is the smallest change of tone intensity, *i e*, the smallest variation of the sound pressure, which is just perceived as a variation of the subjective loudness, that is the absolute difference limen "

"The smallest detectable change in the intensity of a tone determines the intensity differential sensitivity of the ear " (Stevens and Davis [23])

Brinitzer (1935), and Goren de Mare mentioned it in 1939, and Bekesy published his results in 1947 There has since developed a rather large number of variances in testing for the difference limen Bekesy's recruitment test measures the intensity difference limen for loudness at the threshold of hearing When the difference limen is smaller than normal, recruitment is present, when the difference limen is normal, recruitment is absent There has been some criticism of the test, because it is carried out at threshold intensities and the fatigue effect of listening to near-threshold sounds may alter the reaction time of the individual being tested

A similar type of testing was developed by Luscher and Zwislocki, in which the difference limina are tested at well above threshold, namely 40 dbs At this level, the normal difference limen is practically independent of the frequency The greatest degree of accuracy in this test is reached in the middle frequencies from 250 to 4000 cycles, and it is said to be less accurate below and above, especially in the upper tone limit

In 1952, Jerger[10] modified the Luscher-Zwislocki technique somewhat As Bekesy and Reger believe that the greatest degree of recruitment occurs just at and above threshold, Jerger chose a test level close to threshold, namely 15 dbs above threshold, as that intensity level at which recruitment should be carried on Another modification of the difference limen test was developed by Denes and Naunton[1]

The difference limen tests have the advantage over the loudness balance test in that they can be carried out for monaural hearing losses

Luscher's paper was presented on the basis of the examination of 71 patients and he states "The difference limen means a more rapid increase than normal in the subjective loudness when the tone intensity rises, so that in spite of deafness at threshold, loud tones are perceived as being equally loud as in normal hearing The recruitment phenomenon is not in evidence in conductive deafness, and is characteristic of certain forms of perceptive deafness Like the difference limen, it concerns the relationship between the increase of subjective loudness and the increase of tone intensity and, in theory, it may be concluded that the more rapid increase of subjective loudness presupposes a smaller difference limen As the increase in subjective loudness occurs most rapidly immediately above threshold, the phenomenon must be in evidence, particularly at threshold and when the tone intensity is small These theoretical considerations have led to the generally accepted opinion that the recruitment phenomenon and difference limen have the same significance and, furthermore, that the difference limen may be determined instead of the recruitment phenomenon, and, on examination in this instance of 15 patients of different degrees of deafness, have made it clear that the two phenomenona are parallel There is not only fundamentally identical behavior, but also in detail they plot the same curve This furnishes direct proof that the same significance is to be attached to the difference limen as to the recruitment phenomenon and, therefore, in cases of binaural deafness the determination of the recruitment phenomenon may be replaced entirely by that of the difference limen In cases of monaural deafness the determination of the recruitment phenomenon is equivalent to that of the difference limen"

Jerger, in nine cases of sensori-neural loss, performed the difference limen test and the binaural loudness balance test, found that the tests yielded equivalent results, and concluded that abnormally small difference limens and the recruitment phenomenon parallel one another with fidelity Neuberger tested 14 cases of unilateral hearing loss by both the Luscher difference limen test and the alternate binaural loudness balance test and found complete parallelism between the recruitment phenomenon and the decreased difference limen

SECTION OF THE VIIITH NERVE HISTOLOGY OF THE ORGAN OF CORTI

1 Wittmaack, in 1911, reported that the division of the cochlear nerve resulted in degeneration of the spiral ganglion, but that the organ of Corti remained normal

2 Kaida, in 1931, and Hallpike and Rawdon-Smith, in 1934, confirmed these findings

3 Dandy reported his findings of partial section of the VIIIth cranial nerve for the relief of Ménière's disease in 1934 It was reported that frequently no change in auditory threshold occurred, even though large portions of the nerve were sacrificed

4 Schuknecht and Woellner,[21] in 1955, performed partial VIIIth nerve section on cats, and in all instances the histological sections of the organ of Corti were completely normal, except in those cases in which the blood supply had been interfered with In such cases, degenerative changes were observed in the organ of Corti

TUMORS AND/OR PRESSURE ON THE VIIITH NERVE EFFECTS ON THE ORGAN OF CORTI

In VIIIth nerve tumors, the tumor fills the internal auditory meatus and causes a compression destruction of the fibers of the VIIIth nerve There is degeneration of the spiral ganglion within the cochlea, but on the whole the organ of Corti is well preserved These findings in human pathology substantiate the contentions referred to above, namely, that destruction of the VIIIth nerve by tumor or section does not destroy the organ of Corti *per se,* unless the blood supply is interfered with

In Ménière's disease, or hydrops of the labyrinth, there is a dilatation of the cochlear duct The cell mass of the organ of Corti is compressed and Corti's tunnel may be occupied by a structureless coagulum In addition, the normal staining qualities of the cytoplasm and nuclei may be obliterated Histological changes have not been apparent in the peripheral cochlear nerve fibers or in the cells of the spiral ganglion Initially, the pathological process may be reversible and may account for the remissions which are so common in the symptomatology of the disease With the evidence at hand, it seems reasonable to accept the fact that in hydrops of the labyrinth there are definite histological changes occurring in the endolymphatic system, the organ of Corti together with its hair cells, and it is at this site that the disturbance of hearing occurs

ESTABLISHMENT OF THE SITE OF RECRUITMENT COCHLEAR OR RETROCOCHLEAR

Dix and Hallpike[4] investigated 30 cases of clinical Ménière's disease or hydrops of the labyrinth and found the recruitment phenomenon present in all cases The same authors performed the loudness recruitment test in 20 cases of degeneration of the VIIIth nerve Eleven of the cases were of proven neurofibroma and the remaining nine cases were of other varieties of cerebello-pontine angle lesions involving VIIIth nerve function. Of the 20 cases with lesions confined in or about the VIIIth nerve, the recruitment phenomenon was totally absent in 14 and there was slight evidence of recruitment in the remaining six cases.

Eby and Williams, at the Mayo Clinic, investigated 32 cases of Ménière's disease and six with VIIIth nerve neurinomas or other cerebellopontine angle lesions, and their findings with the loudness recruitment tests were consistent with those described by Dix and Hallpike.

Lundborg,[16] using the Bekesy audiometer, investigated 26 cases of clinically diagnosed Ménière's disease and found complete recruitment present in 24 of the 26 cases. Accordingly, Lundborg's findings are in complete agreement with those of Dix, Hallpike and Hood, and Eby and Williams. Lundborg and his colleagues also investigated 21 cases of acoustic trauma, and in all cases the difference limen was strongly reduced, indicating complete recruitment at the frequencies where the hearing loss was evident on the threshold audiogram. Lundborg also recorded the findings in 21 cases of unilateral perceptive hearing loss which were due to retrocochlear lesions, in 18 of the 21 cases, there was complete absence of recruitment, and there was partial recruitment in the remaining three cases.

Jerger investigated 74 cases of sensori-neural losses and determined that there was a small difference limen in all cases investigated where the pathology could be determined or assumed to be in the end-organ, *i.e.*, the sensory receptor mechanism. The difference limina were found to be normal in those instances where the lesion was confined to the cerebellopontine angle.

Luscher's findings indicated the absence of recruitment or normal difference limen in the presence of conductive deafness. Fourteen cases of acute or chronic acoustic trauma showed the characteristic results of a decrease in the difference limen or evidence of recruitment. Similar findings were recorded in six cases of clinical Ménière's disease. Difference limen was normal in five cases of retrolabyrinthine except in those cases in which the blood supply had been interfered with In such cases, degenerative changes were observed in the organ of Corti

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Eby and Williams, at the Mayo Clinic, investigated 32 cases of Ménière's disease and six with VIIIth nerve neurinomas or other cerebellopontine angle lesions, and their findings with the loudness recruitment tests were consistent with those described by Dix and Hallpike

Lundborg,[16] using the Bekesy audiometer, investigated 26 cases of clinically diagnosed Ménière's disease and found complete recruitment present in 24 of the 26 cases Accordingly, Lundborg's findings are in complete agreement with those of Dix, Hallpike and Hood, and Eby and Williams Lundborg and his colleagues also investigated 21 cases of acoustic trauma, and in all cases the difference limen was strongly reduced, indicating complete recruitment at the frequencies where the hearing loss was evident on the threshold audiogram Lundborg also recorded the findings in 21 cases of unilateral perceptive hearing loss which were due to retrocochlear lesions, in 18 of the 21 cases, there was complete absence of recruitment, and there was partial recruitment in the remaining three cases

Jerger investigated 74 cases of sensori-neural losses and determined that there was a small difference limen in all cases investigated where the pathology could be determined or assumed to be in the end-organ, *i e*, the sensory receptor mechanism The difference limina were found to be normal in those instances where the lesion was confined to the cerebello-pontine angle

Luscher's findings indicated the absence of recruitment or normal difference limen in the presence of conductive deafness Fourteen cases of acute or chronic acoustic trauma showed the characteristic results of a decrease in the difference limen or evidence of recruitment Similar findings were recorded in six cases of clinical Ménière's disease Difference limen was normal in five cases of retrolabyrinthine hearing disorders due to cerebello-pontine angle tumors, streptomycin damage and, in one case, hearing loss following mumps

Table I indicates the sex, and the site of the initial symptom, whether cochlear or vestibular, in 28 cases clinically diagnosed as Ménière's disease and in all of which the recruitment test was positive With regard to sex, it would appear from our series that the disturbance is fairly evenly divided, with a slight preponderance in the males It is interesting to note that in 12 of the 28 cases, the primary symptom was cochlear, either a loss of hearing or tinnitus This symptom may in some cases precede by weeks or months the onset of vestibular symptoms In only two of the 28 cases was the primary symptom vestibular without associated cochlear symptoms In half of the cases, the symptomatology suggested that the cochlear and vestibular systems had been involved simultaneously

TABLE I —CLINICAL MENIERE'S DISEASE

Sex	Onset of Symptoms Primary Cochlear	Primary Vestibular	Primary Coch -Vest	Recruitment Ear
M-15	5	2	8	R 7 L-8
F 13	7	0	5	R 5 L-8

PHYSIOLOGICAL AND ANATOMICAL CONCEPTS OF RECRUITMENT

The loudness recruitment phenomenon has been established, on clinical grounds, as indicative of perceptive nerve deafness of the end-organ It is, however, difficult to prove which histologic changes determine the presence or absence of the loudness recruitment phenomenon, because the end-organ and the auditory pathways have not been examined histologically in a sufficient number of instances, and only time and much hard work on the part of auditory histopathologists will clarify the problem

Lorente de No explained the phenomenon in the following terms "If a number of hair cells in the inner ear or a number of fibres in the cochlear nerve are missing, the tones will appear to be weaker in intensity when near-threshold stimuli are used, but, if the intensity of the tone is increased, the more strongly activated hair cells or cochlear fibers will be sufficient to saturate, *i e*, to excite with the limiting intensity the cochlear fiber or the cells of the cochlear nuclei, so that the cerebral cortex will receive the same number of impulses per second from both ears and will perceive the tone delivered to the diseased ear as strongly as the tone delivered to the normal or less affected ear

"Thus, it may be said that Fowler's phenomenon is an immediate consequence of the anatomy and physiology of the nervous system, and that, in fact, it must be pathognomonic of neural deafness"

Stevens and Davis[23] accept the view that the phenomenon of recruitment or, as they term it, the variable type of deafness, is attributable to a deficiency of neural elements These authors report that a hearing loss caused by a masking sound would be of a variable type because the nerve fibers activated by the masking sound would be ineffective in contributing to the sensation of loudness of another tone heard in the presence of the masking noise "Masking is an effective means of decreasing the available supply of neural elements and of producing the equivalent of a variable deafness" By this definition, variable deafness is tantamount to the presence of the recruitment phenomenon

Lurie in 1940, as a result of brilliant experimental work on animals, established the fact that the outer hair cells are more prone to damage from toxins or from acoustic trauma than are the inner hair cells The outer hair cells, of course, lie on the basilar membrane, whereas the inner cells lie directly against the bone The former are presumably more easily damaged as the result of acoustic trauma From a histological point of view, of course, it has been established by Lorente de No that each inner hair cell is supplied by a single nerve fiber, whereas a single nerve fiber has contact with many outer hair cells Lurie conceived that the outer hair cells are sensitive to weak stimulation, whereas the inner cells exist for the perception of more intense stimulation This concept would mean that, with damage to the outer hair cells, the hearing for low intensities would be decreased, however, the presence of intact inner hair cells would presumably lead to a normal loudness sensation for high intensities This could conceivably explain the loudness recruitment phenomenon on a histo-anatomical basis

Patients suffering from acoustic trauma or Ménière's disease conceivably possess the ability of recruitment because weak sounds cannot stimulate the few remaining hair cells and only a minimum number of impulses will be conducted through the acoustic nerve Strong stimulation, on the other hand, is able to stimulate the remaining intact hair cells (presumably inner hair cells) and the impulses are then conducted through the normal fibers of the acoustic nerve and its connections to the cerebral cortex, which then becomes relatively well saturated

Lorente de No, in 1933, described at least a dozen anatomical regions within the cochlear nuclear mass Each cochlear nerve fiber establishes contact with all regions and with many hundreds or thousands of cells The impulses to the secondary auditory pathway are dependent upon the afferent cochlear impulses, and perhaps upon impulses which may be generated within the numerous cells constituting the cochlear nuclei The multiple cellular cortical connections of the secondary auditory pathway allow complete saturation of this area if and when an impulse can be generated in the inner ear, presumably at the hair cell site On the other hand, in retrocochlear lesions there is a relative decrease in the number of functioning nerve fibers, and a strong stimulus has no greater probability than a weaker one of reaching the cochlear nuclei or the auditory cortex The hearing loss is, therefore, as great for weak as for strong sounds and the recruitment phenomenon cannot be elicited

Tumarkin's explanation of loudness recruitment is not unlike that referred to above in the experimental work of Lurie Tumarkin presumes that the basilar membrane is set into activity as the result of sound stimulation, and that the outer hair cells would be stimulated first and the inner hair cells later If some of the hair cells are damaged, the pattern of excitation will be that composed of the remaining hair cells If, however, the intensity of a sound is increased, other viable hair cells may be brought into activity which in turn stimulate the intact acoustic nerve fibers and allow a comparatively greater number of impulses to reach the auditory area of the cortex On the other hand, in deafness due to a disturbance of the acoustic nerve fibers the impulses initiated in the inner ear, likely in the region of the hair cells, are impeded to the same extent for both low and high intensities and because there are no available pathways, there will not, therefore, be any evidence of recruitment

RELATIONSHIP OF RECRUITMENT PHENOMENON TO ADAPTATION

Earlier in the paper it was remarked that perhaps some of the differences of opinion expressed with regard to the reliability of the difference limen test could be explained on the basis of a too prolonged period of testing, with resulting fatigue or adaptation of the nerve receptors

The chief characteristic of fatigue in nerve tissue is the persistence of a reduced response following stimulation, and has its subjective counterpart in human experimentation in the so-called "post stimulatory fatigue" The amount or measure of fatigue is dependent upon the duration and intensity of the stimulation, as fatigue increases, the recovery time becomes longer

"Adaptation" has been described as a process of equilibration—the maintenance of equilibrium between restoration and dissipation of energy Davis states that "It is a special case of fatigue, in that it represents an adjustment to a new level of sustained activity and not an exhaustion of reserve material" Equilibration occurs at practically all levels of stimulation and is a function of the frequency of stimulation but not its intensity Hood[8] has indicated in the human subject that for intensities from 40 to 80 dbs above threshold, which cannot be considered supramaximal stimulation, adaptation reaches a maximum level at about the same time and is independent of the intensity of the test tone

Hood summarizes the differentiation between post-stimulatory fatigue and adaptation as follows "The one (fatigue) is a diminution of hearing acuity caused by a physical stimulus and varying in magnitude with its intensity, and the other (adaptation) is a decline in sensitivity of the hearing receptors consequent upon their physiological activity"

In disturbances of the end-organ of hearing the excitability of the end-organ to short intermittent stimulation may be normal or even increased This "on-effect" is measured with the loudness recruitment or the difference limen test On the other hand, in end-organ deafness the excitability of the nerve to sustained stimuli of even moderate intensities results in a relapse of excitability to a subnormal adapted level It would appear, therefore, that subnormal adaptation to prolonged stimulation and the normal on-effect of excitability to brief intermittent stimulation are characteristic of end-organ deafness, and the two phenomena are likely closely related physiologically

RELATIONSHIP OF RECRUITMENT TO SPEECH INTELLIGIBILITY

It is generally agreed among most authors (Dix, Hallpike and Hood, 1943, Eby and Williams, 1951, Huizing and Reyntjes, 1952[9]) that in nerve deafness in which the recruitment phenomenon is present, speech intelligibility is decreased, as the loudness increases, intelligibility falls off, even with a very slight increase in intensity above threshold On the other hand, in perceptive deafness other than end-organ deafness, intelligibility increases with intensity up to a certain level One should not, of course, expect that every case of nerve fiber deafness will obtain improved intelligibility scores with amplification There will presumably be cases in which the nerve fiber population is too small to carry a sufficient number of impulses towards the acoustic nuclei

SUMMARY

1 Section of the VIIIth nerve or acoustic tumor formation results in degeneration of the spiral ganglion, but the organ of Corti remains normal unless the blood supply is interfered with

2 Ménière's disease connotes a pathological disturbance in the end-organ of hearing, i e, in the sensory receptor mechanism

3 The binaural loudness balance test and the difference limen test yield equivalent results

4 The recruitment phenomenon and/or decreased difference limen results from lesions in the receptor mechanism, or the organ of Corti The phenomenon is generally absent in other forms of perceptive deafness, unless there has been an interference with the blood supply of the cochlea

5 The presence of the recruitment phenomenon should, in the present state of knowledge, preclude the possibility of restorative hearing surgery on the inner ear.

6 The recruitment phenomenon indicates a gross lesion in the end-organ of hearing, with which there is generally speaking a decrease in speech intelligibility The presence or absence of the loudness recruitment phenomenon, therefore, should be of some value in determining the probable usefulness of a hearing aid

7 Persons with conductive deafness due to alterations in the middle ear mechanism do not exhibit the loudness recruitment phenomenon

8 The absence of the loudness recruitment phenomenon in the presence of a perceptive deafness is generally indicative of a retrocochlear localization of the lesion The topographic diagnostic significance of the loudness recruitment phenomenon should not be overestimated, and other investigations should not be neglected however, the loudness recruitment phenomenon and the difference limen test appear, from anatomical, pathological, physiological and clinical points of view, to be valid and reliable They have given the profession a means of differentiating cochlear from retrocochlear lesions in perceptive hearing losses, whether due to injury infection or degenerations, and, as such, have added infinitely to our neuro-otological armamentarium

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PENICILLIN RESISTANT GROUP-A STREPTOCOCCI IN NOSE AND THROAT INFECTIONS

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In a recent discussion of antibiotic prophylaxis the statement was made " that thus far penicillin resistant strains of Group-A hemolytic streptococci have not been encountered"[1] This is with reference to the human equation An indication that all is not well with penicillin from the experimental standpoint is to be found in an article by Eagle,[2] who suggests that a delay in its use for treatment, or a refractory physiological state of the host, may be the reason for the paradoxical treatment failures with penicillin in Beta-hemolytic streptococcal infections in mice

The purpose of this report is to present personal experiences with 22 cases of Group-A streptococcal infections seen in adults and gleaned over the past five years, which were found to be resistant to penicillin, 15 completely so, and seven of varying degrees of sensitivity The Beta-hemolytic streptococcus was isolated in 17 cases, and the Gamma streptococcus or viridans in five (see Charts) All bacteriological work was done in the laboratory of the Georgia Baptist Hospital, Atlanta, Ga , and in each case grouping and typing according to the method of Lancefield was performed The Beta-hemolytic streptococci were all Group-A, Type 4, and all were producers of hyaluronidase Sensitivity testing was done both with the disc and serial dilution *in vitro* techniques Interpretation of these studies in terms of living response and reaction may be fraught with hazard, but in general clinical effectiveness correlates well with the sensitivity tests

The dangers of mishandling antibiotic therapy are still not realized by the majority of practitioners, as an increasing volume of literature on reactions, and even death, witnesses The blithe assumption that "There is no evidence that

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4 Is the microbial agent sensitive to the antibiotic being employed, and does it readily acquire resistance to the drug?

5 Is dual therapy needed or can it be harmful?"

DISCUSSION

Each of the 22 patients had previously received penicillin either orally or by the intra-muscular route, some had received it on occasion two or three years in succession for throat or nasal infection Each was a treatment failure, in that for two or three weeks prior to examination and study they had received from their local physician two or more "shots" of penicillin without effect The complaints ranged from a constant, unabating sore throat or nasopharyngitis, usually attended with mild fever and temperature elevation, to obvious prostration, dyspnea, dyshagia and odynphagia Only the most unusual case of the series will be given in detail here This one was resolved easily by a combination of precise bacteriological technique and serendipity

CASE REPORT

Mrs H a 33 year old housewife had received from her physician in the two years prior to this study a series of penicillin injections for a severe sore throat, associated with marked regional lymphadenopathy Each time her disease had rapidly abated No bacteriologic studies had been done Two days prior to study she had received a "shot" of penicillin which had no effect on her throat Examination of oropharynx revealed a grayish white mucous membrane and a normal larynx Nasopharynx was unobstructed A large thumb sized mass was obvious in the left side of her neck just anterior to the sternomastoid muscle This gland was slightly tender and very firm to the touch She admitted that the node was less tender after the penicillin injection but she now complained of dysphagia and inability to swallow soft foods Water and other liquids were all she could handle Temperature by mouth was 100 degrees F

Because of her apprehension about the difficulty in swallowing she was admitted for observation and a culture was taken During the night she experienced an episode of dyspnea and cyanosis of short interval The next morning laryngeal examination revealed a marked redness to the oropharynx and a pearly whiteness to the larynx which was obscured by a round ping pong ball sized mass apparently arising from the left arytenoid A quick check with the laboratory revealed that the previous day's culture was negative The throat was recultured immediately and planted direct into media at the bedside An emergency tracheotomy was considered but a trial of ACTH and Cortisone was attempted A Levin tube was inserted for feeding she being unable to swallow liquids without severe pain Since penicillin had proved ineffective and not knowing which antibiotic would prevail certainly nothing by mouth or tube, it was decided to give her 2 grams of dihydro penicillin resistance is of much importance in the treatment of Beta-hemolytic streptococcal or certain other infections,"[3] is no longer tenable. Other authors[4] note "No instances of development of resistance by Group-A hemolytic streptococci have been reported in the literature, nor did we encounter any when using monthly courses over a period of five years."

CHART I

Lancefield Group-A	Tetracycline	Chloramphenicol	Erythromycin	Streptomycin	Dihydro-streptomycin	Oxytetracycline
Beta hemolytic streptococcus (17 cases)	8	3	3	1	1	1
Streptococcus viridans (5 cases)	4	—	1	—	—	—

CHART II

Resistance to Penicillin *in vitro* Testing Using 0.5 Units as Standard

Lancefield Group-A	2X	3X	4X	5X
7 Cases	2	3	1	1

The common practice of giving penicillin "shots" for a "cold" is mentioned here only to be condemned.

Mangiarracine,[5] in an excellent article, emphasized the importance, in fact necessity, of accurate bacteriological work with sensitivity testing before the use of any antibiotic. Woodward[6] states that "Before blindly administering an antibiotic, the physician should weigh all eventualities and be prepared to answer several questions.

1. Is an antibiotic really needed?

2. What is the proper drug and how long should it be continued?

3. Is the administration going to affect in any way the ultimate immune status of the patient?

SUMMARY

In view of the fact that it is a commonly held opinion that the Group-A streptococci are almost always responsive to penicillin therapy, these 22 cases in which penicillin was of no value at all should make the practitioner "fall back and regroup" his previous conceptions regarding its use, particularly in respiratory infections

The Beta-hemolytic streptococcus was encountered in 17 cases Tetracycline was the drug of choice in eight, chloramphenicol and erythromycin each three, streptomycin, dihydrostreptomycin, and oxytetracycline one each The streptococcus viridans was found in five cases, tetracycline was the choice drug in four, erythromycin in one There were seven cases of Group-A streptococcal infections in which penicillin was weakly effective, *i e*, it required two, three, four or five times the normal concentration to kill the offending organism

It cannot be emphasized often enough that, in the management of any infection, before administering an antimicrobial agent, a smear from the involved region, culture and sensitivity testing should be done, and then only should the most effective drug be used

Before giving any drug the practitioner should review the five precepts of Woodward outlined above

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streptomycin I.M. empirically. In four hours dysphagia was less and she was more comfortable. No tracheotomy was needed.

Eighteen hours after the second culture was planted the growth was found to be Beta hemolytic streptococcus, and the *only* antibiotic which was effective at all was dihydrostreptomycin. She was continued on this drug for three days, as well as on Cortisone for the laryngeal edema. Local heat in the form of the large wet pack hydrocollator to the left side of the neck was used in addition, and in four days she was free of discomfort. The mass in the neck was pea sized and the larynx had returned to its normal configuration at the time of discharge from the hospital.

In each instance the only comment that can be made is that prior to bacteriologic studies the patient had been in discomfort so that the normal performance of job, or housework, was impaired, and that at the conclusion of specific antibiotic therapy each had returned to a state of what to them was considered normal health and no discomfort was present.

A distinction should be made between the development of resistance by the streptococcus during the course of treatment with penicillin, and the infestation of the human economy with an organism that was resistant to penicillin from the outset.

In the opinion of the writer it is the latter aspect of the penicillin problem that is more important. It behooves the physician first to realize that such a state of affairs exists; second, since penicillin reactions are being reported more and more frequently, that he should culture and have sensitivity tests beforehand, and only *then* give the most effective antimicrobial agent as shown both by the disc and *in vitro* serial dilution techniques, third, that penicillin is the most common offender in causing thrush or moniliasis of the mouth and tongue, and therefore, should be used with caution, "covering" it with large doses of B-complex and mycostatin tablets, or suspension, or both concurrently. Gentian violet may often have to be used to control this complication. In the author's routine daily office practice oral moniliasis is seen in over 50 per cent of patients. This varies from groups of white patches on the buccal mucous membrane and palates, to the yellowish brown to black hairy tongue. In most instances each patient had received from another physician one or more "shots" of penicillin only to be made worse, with specific reference to the throat.

using the arterial blood pressure from muttons," which illustrates medical progress in another field since that time

The entire procedure of total laryngectomy took Dr Billroth one hour and 45 minutes

The patient a 36-year-old teacher with a tumor below the true vocal cords was first treated with multiple cauterizations and biopsies (microscopic report epithelial carcinoma of the larynx) On November 21 1873 (after a preliminary tracheotomy), Dr Billroth performed a laryngofissure and removed the tumor with scissors and sharp curette The main tumor was situated on the left side so the surgeon was able to preserve the right vocal cord, the wound edges were approximated with tape On the second postoperative day the patient began to have septic temperatures and infection developed in the wound, which was treated with a preparation containing silver nitrate on the seventh postoperative day the patient was up and about and two days later a high degree of dyspnea developed The wound was reopened and examination revealed that the growth had recurred

In an attempt to curette the larynx Dr Billroth reopened the wound but discovered that the malignant growth had invaded the cartilage The patient was awakened informed of the necessity to remove the larynx and again anesthetized The technique consisted mainly in dull dissection of the larynx on both sides while the assistant exerted a pull on the larynx The trachea was divided just below the cricoid the larynx was pulled forward and up and dissected from the anterior wall of the esophagus the thyrohyoid membrane was divided last The anesthesia was not sufficient and the operative procedure was frequently interrupted by strong coughing spells during which blood in rather large amounts was expelled from the trachea The bleeding was controlled by pressure with large sponges

The growth must have been quite large since after examining the specimen, Dr Billroth decided to remove most of the epiglottis and the first two tracheal rings The tracheal stoma was fixed to the skin with one suture on each side and the opening into the pharynx was made smaller by applying three sutures Four hours later during a bout of coughing, a profuse hemorrhage developed from the left superior laryngeal artery which required a ligature Dr Gussenbauer[1] remarked about the large amounts of coagulated blood which the patient had coughed up without having had great signs of dyspnea Three days after the operation the sutures and the ligatures were removed The wound represented a groove with the tracheal stoma in the lower end and the opening into the pharynx on the upper end

Fortunately the patient escaped all secondary complications such as shock, aspiration pneumonia mediastinitis sepsis meningitis, tetanus and large abscess The pharyngeal fistula began to close early, and the patient was started on a soft diet on the eighth postoperative day, the gastric feeding tube was removed on the eighteenth day The patient was dismissed on March 3, 1874, after he had learned how to use the artificial larynx designed by Dr Gussenbauer (see Fig 1) Unfortunately, a recurrence of the lesion with metastatic nodes developed and the patient died approximately one year after the operation

The second recorded total laryngectomy for carcinoma of the larynx was performed in April, 1874, by Dr Heine[3] of

SOME HISTORICAL NOTES ABOUT THE FIRST LARYNGECTOMIES[*]

ADOLF W SCHWARTZ, M D ,
and
KENNETH D DEVINE, M D ,

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Long before the discovery of blood groups, without knowledge about electrolytes, without the intravenous use of fluids, and before antibiotics and other modern drugs, great surgeons performed operations which still belong among the most difficult, as well as major operations Almost a century has passed since the first successful laryngectomy was performed, and today, 85 years after performance of the first recorded total laryngectomy on a patient by Dr Billroth,[1] a review of his results, technique, and of some of the experience of this father pioneer surgeon should be of some historical interest

Before this operation took place, Dr Czerny[2] had performed experimental laryngectomies on dogs, he also had constructed a T-shaped tube which he placed in the wound to serve as an "artificial voice box" In 1829 Dr Albers[3] recorded the successful extirpation of the larynx of a dog which lived for nine days Drs von Langenbeck[3] (1854), Koberle[3] (1856) and Hueter[4] discussed and proposed the laryngectomy, but it was not before December 31, 1873, that Dr Billroth performed the first laryngectomy on a human being The detailed description was presented by Dr Billroth's assistant, Dr C Gussenbauer,[1] to the Third Congress of the German Surgical Society on April 11, 1874 It is interesting to find also that on the day before this presentation to the Third Congress, Dr Kuster[4] presented to the same congress "a newer method of blood transfusion from animals to humans,

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[*] The Mayo Foundation Rochester Minn is a part of the Graduate School of the University of Minnesota

Editor s Note This manuscript received in The Laryngoscope Office and accepted for publication October 10 1958

The first successful laryngectomy with many years of survival was performed on a 24-year-old man in 1875 in Italy by Dr Bottini[3] The lesion was a mixed round and spindle cell sarcoma The patient lost a large amount of blood and erysipelas developed, but he survived, and for years he was able to continue his work as a mail carrier in a mountainous region

Notable advance in the technique of total laryngectomy was reported by Dr von Langenbeck.[7] On July 28, 1875, he presented an unusual specimen during the meeting of the Medical Society in Berlin It included the entire larynx with epiglottis, hyoid, a third of the tongue, the anterior and lateral portion of the pharynx, a portion of the esophagus, both submaxillary glands and lymphatic tissue from the submaxillary triangle A 57-year-old man with carcinoma of the larynx had undergone tracheotomy but refused to have a laryngectomy He returned seven months after the operation, and on July 21 was operated on by Dr von Langenbeck The incision was T-shaped The dissection was performed from above, so that the trachea was severed last The time involved was a little more than two hours It is recorded that the operation was done as exactly as an anatomic dissection, and in spite of the extensive region involved, the blood loss was unusually small, because each vessel was ligated prior to being cut Forty-one ligatures were made, including both external carotid arteries, lingual, facial, superior thyroids, etc The patient survived for four months but died on November 23, 1875, of collapse during an attempt to remove the metastatically involved glands of the left side of the neck This operation of Dr von Langenbeck could be considered the forerunner of the combined wide-field laryngectomy and neck dissection

It would be too much to list each laryngectomy in the following years, but mention of one is worth while Again it was Dr Billroth who, in July, 1878, performed the surgical removal of half of the larynx He was probably the first to do a hemilaryngectomy, or partial laryngectomy In this patient only the left side of the larynx was removed

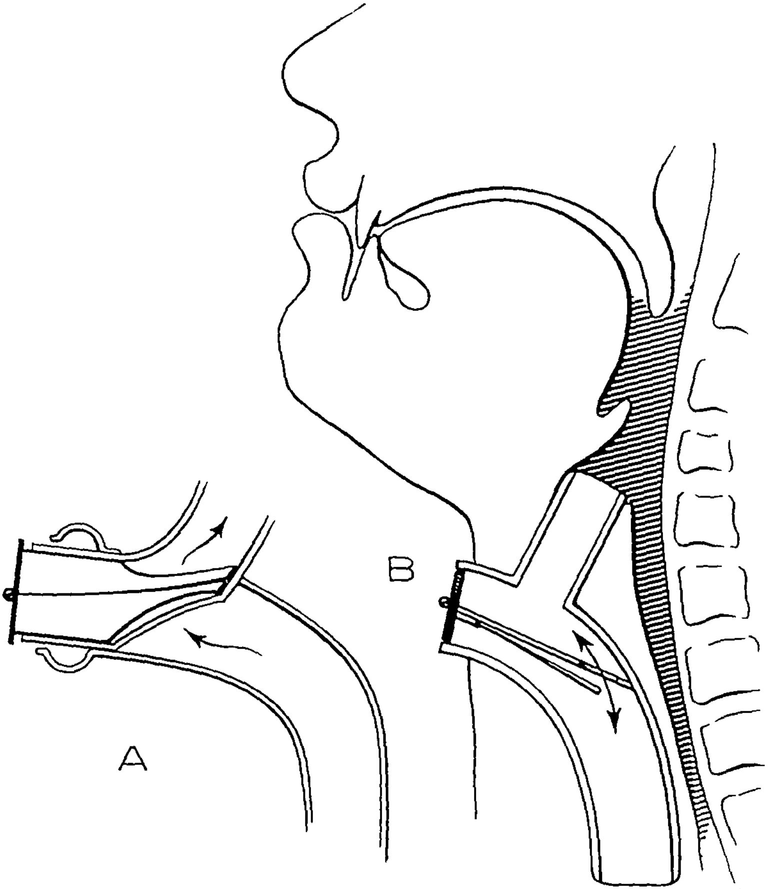

Fig 1 A—Gussenbauer's 'artificial larynx' with a metal membrane B—A modification by Foulis (Adopted from M Schüller 1880)

Prague The patient survived for six months, in June of the same year Dr Maas[5] of Breslau performed the third laryngectomy Pneumonia developed, and the patient died two weeks after operation Dr Schmidt[6] of Frankfurt performed the fourth laryngectomy on August 12, 1874, but the 56-year-old patient survived only four days and died of collapse Dr Billroth performed his second total laryngectomy combined with removal of a small goiter on November 11, 1874, on a 54-year-old man The patient suffered preoperatively of bronchitis and died of bronchopneumonia on the fourth day after operation midline, the larynx was isolated mainly by blunt dissection aided by a strong pull on the larynx anteriorly, or to the opposite side of the dissection The separation was started mostly from above and carried through the plane of separation from the anterior esophageal wall, the trachea was then cut posteriorly This is not exactly the technique used by Dr Billroth, and many modifications soon developed

The principle of the postoperative treatment in those early days was to leave the wound wide open The wound was packed with sponges soaked in carbol solution to soak up the saliva and the wound secretions The outer dressing produced counter pressure to eliminate dead space The trachea was anchored to the skin with a few silk sutures, and the tracheal cannula was inserted The dressings were changed daily, and the wound was irrigated with carbol solution

The oral cavity was washed out several times daily with disinfectant solutions, and the patient was fed by a gastric tube A steam kettle evaporating turpentine oil with carbolic acid and glycerine was placed in the room In those days it was a common procedure to introduce an artificial larynx into the wound in the early postoperative period

ARTIFICIAL LARYNGES

The early artificial larynges were of various design, but most of them incorporated a vibrating membrane in the course of a tube connecting the tracheal stoma with the pharyngeal stoma The membranes were of ivory, horn, silver, copper, or hard rubber, but all had the disadvantage of soon being covered with thick mucus and all presented an obstacle to breathing and talking Saliva and food particles easily entered the trachea producing violent coughing spells Dr Billroth placed the artificial larynx in his first patient on the twenty-first day after operation, Dr Maas placed his on the eleventh day, Drs Heine and Czerny on the ninth and Dr Schmidt[6] immediately after removal of the larynx Generally, however, a period of two weeks was adopted as

TECHNIQUE

In the first ten years after Dr Billroth's successful laryngectomy, the advantage of a preliminary tracheotomy (performed, if possible within a few weeks to months before the main operation) was soon recognized The Trendelenburg position, the Trendelenburg cuffed tracheotomy tube (see

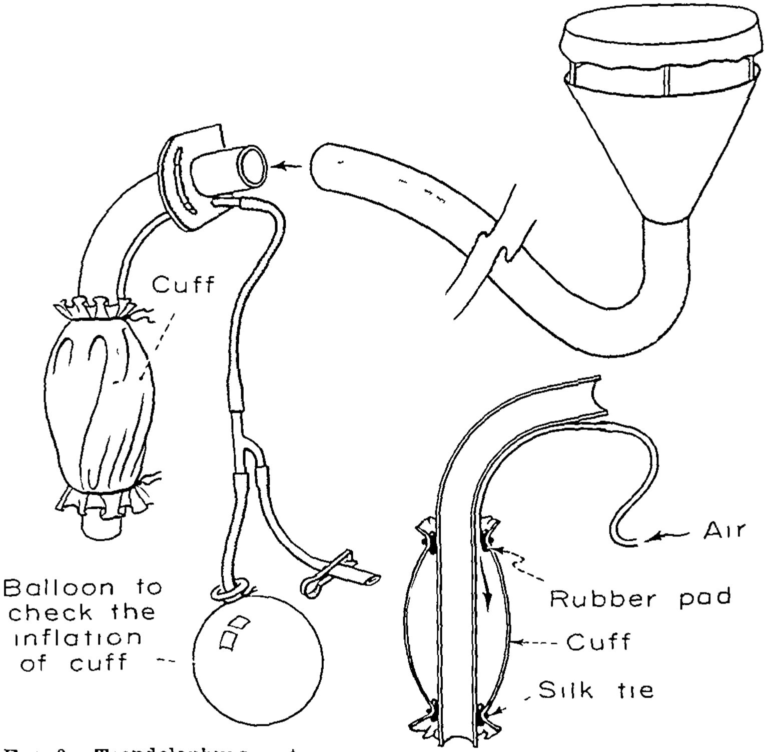

Fig 2 Trendelenburg's tampon-cannula used for oral operations and operations on the upper respiratory tract as early as 1865 to 1870 Chloroform was sprayed on gauze over funnel (Modified after M Schüller 1880)

Fig 2), and the use of cautery on bleeding points were soon recognized as great technical aids The incisions in the first three or four operations were mid-longitudinal, but Dr von Langenbeck extended his incision laterally to the medial border of each sternocleido muscle and produced a T-shaped incision After penetration through the muscle layer in the

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POST GRADUATE COURSES AT TEMPLE UNIVERSITY SCHOOL OF MEDICINE AND HOSPITAL

A Postgraduate Course in Bronchoesophagology, February 16th to 27th, 1959, and a Postgraduate Course in Laryngology and Laryngeal Surgery, April 13th to 24th, 1959, will be given by Temple University School of Medicine

These courses are to be given in the Department of Laryngology and Broncho-Esophagology, Temple University Medical Center, under the direction of Drs Chevalier L Jackson and Charles M Norris

The tuition fee for each course is $250 00 Application blanks and further information concerning dates of subsequent courses may be obtained by writing to Jackson-Research, Laboratory 604, Temple University Medical School, 3400 N Broad Street, Philadelphia 40, Pa the most suitable time, and soon it was made evident that speech was possible without an artificial larynx

The purpose of this article is to describe the first steps taken toward the well-developed technique of total laryngectomy as used today In the early days, total laryngectomy was considered to be an exceedingly dangerous operation Between 1881 and 1888, Dr Sendziek[8] collected data of 110 total laryngectomies, and between 1888 and 1894 only 47 It should be mentioned briefly that with the publication of Dr Rontgen's communication on a new kind of rays[9] in 1898, and with the isolation of radioactive substance by his assistant Dr Maria Sklodowska (later Madame Curie), the surgical treatment of malignant involvement of the larynx was soon more and more frequently replaced by radiation therapy The higher rate of complications and the high mortality rate due to surgical treatment strengthened the hand of the radiologist and reversed the trend toward increasing surgical intervention in carcinoma of the larynx

Among the few who stood out in favor of surgical intervention were Drs Jackson,[10] Lewis,[10] Thomson,[11] New[12] and others The general surgeons were conspicuous by their absence, and it was not until the advancement in medicine of the last 20 years that total wide-field laryngectomy became widely accepted as a standard procedure in the treatment for cancer of the larynx

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appreciation for things whimsical by their very quaintness One could appeal to the nobler instincts by a lengthy discussion of how such a study might prove intellectually broadening, stimulate new interests, fill cultural gaps and help burnish off any remaining ragged burrs of knowledge concerning one's chosen field of study One could choose the easy road by simply calling it a hobby and thinking of it as fun

Words, both conversational and scientific, take their origin

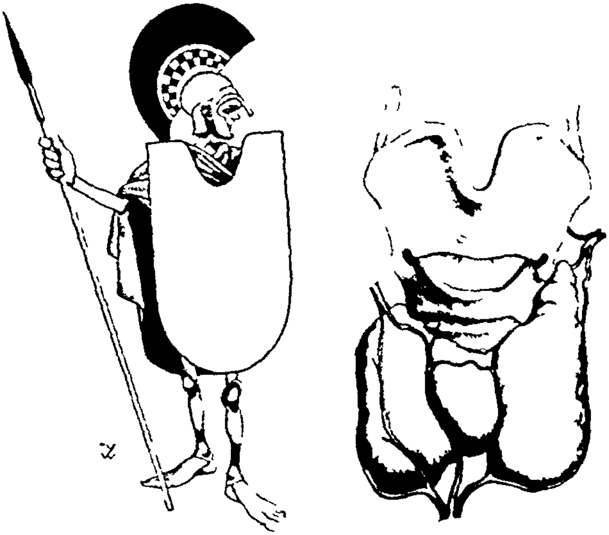

Fig 1

from many sources The exact source may be unknown or at best controversial Some come down to us, more or less intact, from the mouths of the ancients There are those which are misnomers and others which have gradually evolved by being passed from one racial or cultural stock to another, while many of our words were, and still are being, "coined" by present day scholars

Sanskrit, the ancient Aryan language of the Hindus of India, is of special interest to students of philology It retains many of the characteristics of the parent Indo-European

ORIGIN OF OTORHINOLARYNGOLOGIC TERMS

Gene V Williams, M D ,

Kansas City, Kans

The physician is frequently confronted with the question, "Why do doctors use such big words and what do they mean?" The reaction of the doctor to this usually abrupt and often petulant query may vary from arrogant intellectual impatience to shoe-scuffing self-modesty Occasionally he finds himself hopelessly cornered and is forced to admit honestly, at least to himself, that he just does not know what a particular word means As a case in point he undoubtedly knows what the thyroid gland is and what it does, he could quite probably describe the organ ad nauseum What he may or may not know is that the word thyroid is derived from a Greek word which applied to a particular type of shield This long shield which had a deep notch at the top for the chin was carried exclusively by the Minoan foot soldiers of ancient Crete, and its singular shape suggested to Galen the name for the cartilage in the neck The gland takes its name in turn from that of the cartilage (see Fig 1)

Upon hearing such a tale as this the busy clinician will probably counter with something to the effect that he knows perfectly well the anatomy and physiology of the structure in question He may further declare that it is not only unnecessary for him to clutter his mind with such trivia, but also that he just plain doesn't give a hoot what word the Greeks had for it One must admit he has a point, however, the true meaning and derivation of the words commonly employed in medical circles can be very interesting

These words are often descriptive, thus facilitating the conjuration of a mental image of the anatomical part They may be of historical interest or simply tickle one's sense of

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*From the Department of Otorhinolaryngology of the University of Kansas School of Medicine

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the Sixteenth Century The procedure was called a "Bronchotomy" until 1718 when Heister introduced the term "Tracheotomy"

The word bronchus is said to be derived from the Greek word meaning to "pour or moisten" This is the result of an ancient belief that solid foods were carried to the stomach via the esophagus and liquids by way of the bronchi

Parotid simply means "beside the ear" and refers to the parotid gland The function of this gland was first demonstrated by Stensen in 1662

Isthmus, though Latin, is from the Greek word meaning a narrow passage or opening, and also refers to a neck of land separating two bodies of water

The earliest source of the word "Pharynx" is uncertain, but opinion allies it to the Greek word meaning "Gully or ravine" Galen defined the pharynx as the common opening of the gullet and windpipe The word first appeared in English medical terminology in 1693

The derivation of "Palate" is also questionable It may be associated with pascere, "to feed," or, because the palate is surrounded by teeth, to palere, "to hedge in" Skeets says the root is uncertain, but Campbell believes it refers to Palatine Hill in Rome In his opinion, the hill takes its name from balatans, "bleating," because of the bleating flocks that grazed there in antiquity Most authorities feel that it is much less complicated and that Palatine is derived from palatium, "a palace" Before Fallopius differentiated between the hard and soft palates, they were jointly referred to as the "diaphragm oris"

Helix means a spiral, twisted, or coiled structure, and was used by Theophrastus some twenty-three Centuries ago in referring to the tendrils of vines Aristotle employed the word when describing convolutions of the snailshell and loops of intestines (see Fig 2)

The hyoid, "U-shaped," bone was first named and described by Herophilus, a Greek physician born in Alexandria in 344 B C (see Fig 3) language Antrum, the Latin word for cave or cavity, is from a Greek word which was in turn derived from an earlier Sanskrit word meaning "within" The maxillary and frontal sinuses were noted and recorded by Leonardo da Vinci Casserius, during the latter half of the Sixteenth Century, referred to the "Antrum Maxillae" The maxillary sinus was later called the "Antrum of Highmore" after the Seventeenth Century English naturalist Genu, the Latin word for knee, is related to the Greek "gony" Both words are probably derived from the Sanskrit word "Janu" The geniculate body, being located on the facial nerve where it makes a "knee-like" bend in the facial canal thus becomes a more meaningful term

The word "nose" is of uncertain origin, but arises from a root common to many languages The Sanskrit word, nasa, the Latin, nasus, the Anglo Saxon, nosu, the German, nase, the Italian, naso, and the French nez are but a few examples

The ancient Greeks had many words for many things Carotid is derived from the Greek word meaning to "throttle or stupefy" During the First Century of the Christian era, Rufus of Ephesus referred to the ancients' awareness of "sleep" resulting from pressure being applied to the vessels of the neck Referring to a blood vessel as an "Artery" stems from the ancient notion that these vessels contain air The blame for this misconception is usually laid at the feet of Praxagoras, but one should not be too harsh in his judgment of the poor fellow, because Erasistratus agreed with him It seems that Herophilus knew the vessels contained blood, but even with Galen supporting him the idea of air in the arteries persisted for a long time

Since, to the ancients' minds, the windpipe was "also" an air-containing tube, it was called the "Arteria Trachea," or rough artery Very early in the Sixteenth Century, the word "Arteria" was dropped, and the windpipe was referred to simply as the trachea Making an opening in the trachea was first advocated by the followers of Aesculapius, and may have been performed by Paul of Aegina and Antyllus, however, the first recorded instance of a successful performance of this operation was by Brasovolus during the first half of

We have words which are the result of "slips of the pen," for example, the word lacrimal is a Latin word meaning "tear." It is probably a misnomer due to an ancient scribe's error in copying "lakry" for "dakry," the Greek word for tear. In support of this "careless scribe theory" some scholars state that there is an older form of the Latin word spelled d-a-c-r-i-m-a. The term "lacrimalis," first appeared in the English language some time before 1400.

There exists a rather lengthy list of words, commonly employed in the practice of medicine, which one might refer

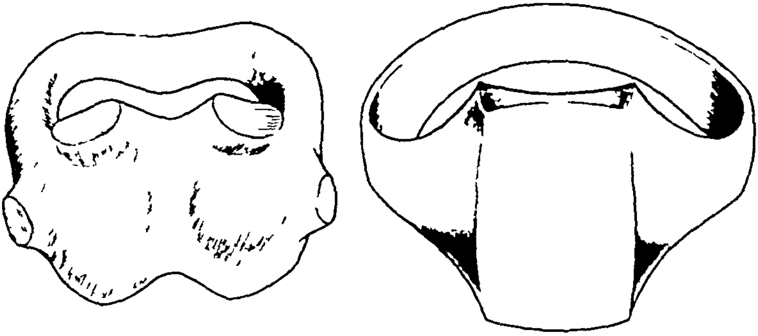

Fig. 4

to as "Galenisms." Claudius Galen, often called the "Prince of Physicians," though more often referred to as just plain "Galen," was born in 130 A.D. at Pergamos. His father, Nikon, was an Asiatic Greek, and it is said that little Claudius inherited his mother's irritable temper. Galen removed to and settled in Rome when 30 years of age, and he became a famous physician as well as a prolific writer. His words were concerned, for the most part, with his own observations and experimentations, but he also found time to write a summary of the anatomical knowledge of his day. He died a septuagenarian in Sicily but remained influential from the grave. For 1,400 years he continued as the leading medical authority of the Christian world. Such anatomical structures as the ethmoid, "sieve-like," and sphenoid, "wedge-shaped," bones, as well as the pterygoid, "wing-like," and mastoid,

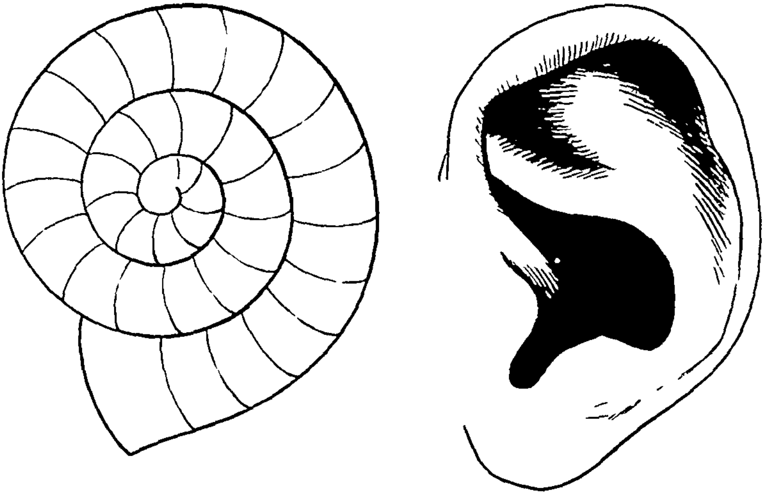

Fig 2

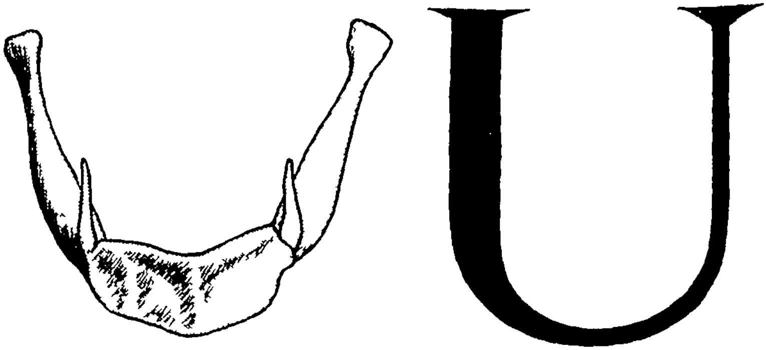

Fig 3

One Julius Pollux, an obscure Greek author who lived from 134 to 192 A D , bequeathed his "Onomasticon," or "Vocabulary" to posterity One section of this work concerns itself with medical terminology The vocabulary was reprinted in 1502 and became an important source of words for those translators who busied themselves by replacing Arabic with Greek and Latin words Such words as cricoid (see Fig 4), meaning "ring-shaped" and tragus, meaning "goat," so named because of the hairy nature of the skin in this area, were introduced by Julius Pollux

There are many descriptive words in Latin Lingua, which means tongue, is said to be imitative of the sound produced by licking with the tongue Another descriptive Latin word is vomer, which means "ploughshare" The word is supposedly derived from vomere, "to vomit," because the plough "throws up" the newly broken soil to the side The resemblance of the bone of the nasal septum to a plough-share is obvious (see Fig 5) Piriform means "pear-shaped" Uvula, meaning "little grape," is a term which was not used by the ancients This dangling mid-line structure was called the "pillar" by the Greeks and "columella" by the Romans Guy de Chauliac, a French surgeon, who practiced in Avignon during the first half of the Fourteenth Century, introduced the term "uvula" Frenulum is the diminutive of fraenum meaning "bridle" Bulla means bubble or ball Crus, which refers to the shin or leg, is applied to any leg-like structure (see Fig 6)

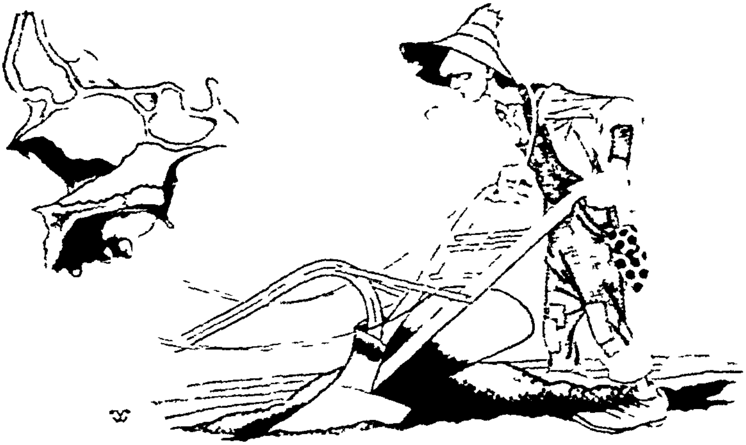

Fig 5

The Anglo-Saxons have given us such words as ear, from eare, nose, from nosu, and nostril, from nosethyrl Tongue is from an earlier Teutonic root, tonga or tunga "breast-like," processes were first described and named by Galen He observed that, in certain animals, the appearance formed by two small cartilages in the larynx, when covered by mucous membrane, was not unlike that of the mouth of a pitcher, therefore, the term arytenoid, meaning "pitcher-like," was applied to the cartilages Galen first used the word glottis, the Attic form of the Greek word meaning "tongue," but also the name of the reed on a wood-wind instrument, as in the modern sense, meaning the mouth of the windpipe

Hot on the heels of the Greeks tramped the Romans Much of our medical vocabulary is Latin in origin The etymology of malar, meaning "cheek," is uncertain Association with malum, an apple, has been suggested The term is also said to be a contraction of maxilla Another word of debatable etymology is ala It is suggested that it may be a contraction of axilla, as mala is perhaps a contraction of maxilla It is interpreted as meaning "wing" or any side compartment Our word tonsil is derived from the Latin tonsilla, meaning a "mooring stake" or any sharp-pointed pole stuck in the ground Removal of the tonsils was described in the First Century by Celsus, who advocated enucleation with the finger "Tonsillectomy" is a hybrid Greco-Roman term Since the tonsil was once known as the "almond of the throat," pure Greek might be amygdalectomy or "removal of the almond" Sinus is Latin for anything hollowed out or curved, and is thus used for various unrelated structures Mucus is a Latin word from the Greek word meaning "slime" Meatus, meaning a passage or channel, takes its origin from meare, "to go" or "to pass" From the Latin word tempus, meaning time, comes the English word temple Both probably originate from the Greek word meaning "to cut" The temple was considered as a fatal and vulnerable spot whereupon a blow might well "cut off" one's life The often-observed phenomenon of hair beginning to turn gray in this area emphasized the relationship of the area to fleeting tempus, or time Jugular is from jugulum, the Latin word for throat Jugulum is, in turn, derived from jugum, or yoke, because a yoke is carried on the neck by Fallopius in 1550 The name, of course, refers to the semi-mythical Cretan maze erected by Daedalus, within whose structure prowled the cannibalistic Minotaur, a monster half bull and half man, which was eventually destroyed by the hero Theseus

Some structures have been given the names of those scholars who helped shed the light of knowledge upon them The tubular connection between the pharynx and middle ear was known to the ancients, having been dissected by Alcmaeon in 500 A D and described by Aristotle The name Eustachian tube was given it by Val Salva in honor of Bartholommeo Eustochio, in 1704

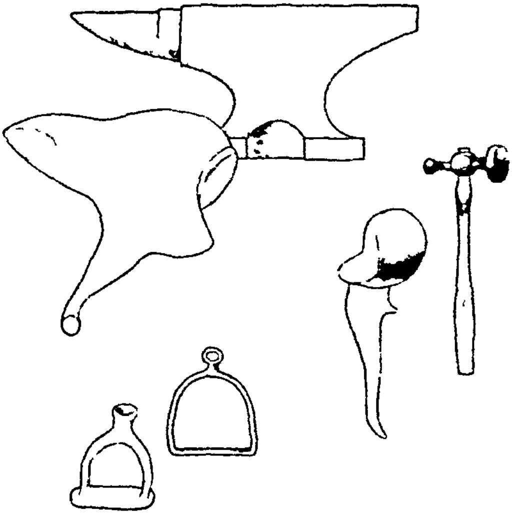

Fig 7

Hypertrophied lymphoid tissue in the nasopharynx was first described by Hubert Von Luschka during the latter half of the Nineteenth Century The name adenoid, meaning "gland like," was not, however, new Adenoides or corpus adenoides was an old term for the prostate gland

In finding one's self so far afield from those regions which

The meanings of the Latin names for the three small ossicles found in the middle ear are familiar to all. Gabriello Fallopius accredited Berengarius of Capri, an Italian anatomist and surgeon, of the late Fifteenth and early Sixteenth Centuries, as the first to describe two of these small bones. Some authorities give this credit to Achillini of Bologna, an elder contemporary of Berengarius. Whoever may have been the first to observe and describe them, Vesalius, noted the similarity in appearance of one of them to an anvil and the other to a hammer. He named them the incus and malleus respectively in 1543. In 1546, Ingrassias, an Italian anatomist, named the third stirrup-shaped ossicle the stapes. This third ossicle was not mentioned by Vesalius. The word stapes is known to be late Latin, because the Romans rode their horses "bare back." Stirrups suspended from the saddle did not appear on the scene until the Fourth Century (see Fig. 7).

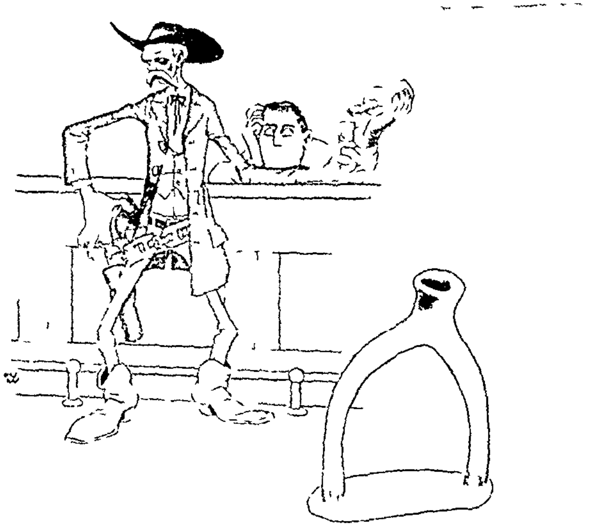

Fig. 6

Though Galen noted it and Vesalius described it, the name "labyrinth" was given to the coiled structure in the inner ear

PROGRAM FOR THE SCIENTIFIC SESSION OF THE THE AMERICAN LARYNGOLOGICAL, RHINOLOGICAL AND OTOLOGICAL SOCIETY, INC

March 10, 11, 12, 1959

"Neck Dissection A Clinico-Anatomical Study of 200 Cases"
George F Reed, M D, Boston, Mass

"Evaluation of Laryngectomy with Radical Neck Dissection"
John J O Keefe, M D, Philadelphia, Pa

Open Discussion

"Progress in Parotid Surgery."
Robert E Boswell, Dayton, O

"Cystadenolymphomas of the Parotid Gland"
John F Daly, M D, New York City

Open Discussion

"Experience with Trans-Septal-Sphenoid Subtotal Hypophysectomy in Advanced Breast Cancer."
Walter E Heck, M D, Robert C McNaught, M D; Leonard G Dobson, M D, (by invitation), and Francis S Greenspan, M D, (by invitation), all of San Francisco, Calif

Open Discussion

"The Problem of Sinusitis in Children"
Victor R Alfaro, M D, Washington, D C

Open Discussion

"Endocrine Aspects of Meniere's Disease"
George E Shambaugh, Jr, M D, Chicago, Ill

Open Discussion

"Cholesteatoma of the External Auditory Canal"
Lester A Brown, M D, Atlanta, Ga

Open Discussion

are the province of the otorhinolaryngologist it is perhaps apropos that the discussion be concluded This is not, by any means, submitted as an exhaustive etymological study It is presented more as a stimulus to those who are susceptible, and as an appetizer for those whose intellectual palates have not been displeased

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ALUMNI ASSOCIATION OF THE NEW YORK EYE AND EAR INFIRMARY

The Annual Spring Meeting of the Alumni Association of the New York Eye and Ear Infirmary last April was so well received that it has been decided to expand next year's meeting, which will take place from April 20-23, 1959

Symposia and lectures on Hearing Rehabilitation, Endoscopy, and Ear Surgery will be conducted It is also planned to offer refresher courses in Mastoid and Fenestration Surgery and Stapes Mobilization Techniques

More complete information regarding the meeting will appear in a later issue of THE LARYNGOSCOPE

PROGRAM OF THE NINETY-SECOND ANNUAL MEETING OF THE AMERICAN OTOLOGICAL SOCIETY.

Hot Springs, Va, March 13-14, 1959

The Cochlear Potentials and Their Relation to Hearing
E Glen Wever, Ph D

More About the Physiology of the Cochlea
Hallowell Davis, M D

Audiometry by Electroencephalography
A J Derbyshire, M D (by invitation)

Ototoxicity of Kanamycin
J E Hawkins, Jr, Ph D (by invitation).

A Cause of Sudden Deafness
William Saunders, M D (by invitation)
William Libby, M D (by invitation)

Acoustic Trauma Following Intermittent Exposure to Tones and Noise
Walter Covell, M D (by invitation)
Don Eldredge, M D (by invitation)

An Experimental Study of the Dynamic Circulation of the Labyrinthine Fluids of Living Mammals
Francis L Weille, M D,
John W. Irwin, M D (by invitation)
Coza Jako, M D (by invitation).
Patricia Palmer, A B (by invitation)

Long Term Results from Surgery for Otosclerosis
Theodore E Walsh, M D

Ultra-Sonic Therapy of Meniere's Disease
Franz Altmann, M D

Presbycusis
Edmund P Fowler, M D

"The Diagnosis and Treatment of Facial Paralysis, Secondary to Basal Skull Fracture"
Miles L Lewis, Jr, M D, New Orleans, La
Open Discussion

"Temporary Obstruction of the Arterial Supply of the Labyrinth"
Henry Perlman, M D, Chicago, Ill
Open Discussion

"Otolaryngologic Aspects of Cerebrovascular Disease"
Bruce Proctor, M D, Detroit, Mich
Open Discussion

"Juvenile Nasopharyngeal Angiofibroma"
Maurice Schiff, M D, Oakland, Calif
Open Discussion

"Late Hearing Results in Mobilization Surgery"
Samuel Rosen, M D, New York City, and
Clair M Kos, M D, Iowa City, Ia
Open Discussion

"Trends in Mobilization Surgery"
Howard P House, M D, Los Angeles, Calif

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EXPERIMENTALLY INDUCED ANKYLOSIS OF THE STAPES*†‡

RICHARD J. BELLUCCI, M.D.,
and
DOROTHY WOLFF, Ph.D., (By Invitation),
New York, N. Y.

Research on human deafness has been hampered by the fact that no lower animal has ever been known to be subject to the disease of otosclerosis. Clinical manifestations of conductive deafness, the most common aspect of otosclerosis, are admittedly accompanied by demonstrable ankylosis of the stapediovestibular joint or the other ossicular joints.[1,2]

If experimental ankylosis could be induced, one further step in research on otosclerosis might be accomplished.

In the course of our investigations on the effects of various types of trauma to the region of the oval window, the authors decided to study the effect of an electric cautery needle applied to the area. The results of simple mechanical trauma were reported before the American Otological Society in May, 1958.[3]

Accordingly, the middle ears of eight cats were opened under nembutal anesthesia. The oval window and the stapes

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*Read at the Meeting of the Eastern Section of the American Laryngological, Rhinological and Otological Society, New York, N. Y., Jan. 8, 1959.

†This work was made possible through a research grant from the Public Health Service, U. S. Department of Health, Education and Welfare.

‡From the Otological Research Laboratory, Manhattan Eye, Ear and Throat Hospital, New York.

Editor's Note: This manuscript received in The Laryngoscope Office and accepted for publication Jan. 19, 1959.

were clearly observed and mobility of the stapes verified in each case.

A Cameron Cauterodyne was used for the experiment. The Cameron Company states that this machine operates at a radiofrequency of 48 meters, and makes five million oscillations per second. "Cold" cutting and/or "cold" coagulation may be used. The depth of coagulation into the tissue is, according to the company, from $\frac{1}{4}$ of 1 mm. to 5 mm. respectively. "When using the cutting current at scalpel speed, healing by first intention may be expected, since only the lymphatics and capillaries are sealed with that type of cutting current. The coagulation is the type that causes no necrosis as may also be expected from the cutting current. No dehydration is formed beneath the coagulum with this type of current."

The needle used was completely insulated except at the tip, and coagulation occurred exactly at the tip. The effect was point-to-point, not diffuse.

The temporal bones of six cats (eleven ears) have now been processed and examined under the microscope. Postoperative time ranged from 24 hours to over six months. The results, in terms of ankylosis and of bone changes as a result of the touch of the cautery needle, which was set at "high," were so uniform and unusual that they merit a special presentation.

The reactions of the cats were observed following this procedure, and occasional movies were taken. No records of cochlear microphonics or electric potentials were taken. Crude observations were made in regard to hearing.

We produced ankylosis of the stapediovestibular joint in five of a possible eight ears. In two the stapes was removed from the oval window, and in one case death occurred the day after the second ear was operated upon. In some instances the incus became ankylosed to aditus and to malleus. In one instance incudostapedial ankylosis was effected. In three ears the stapedial crura were obviously replaced by fibrous tissue.

In addition to ankylosis, we have, in one ear, produced a greatly thickened and vascularized footplate of the stapes

In all but two of the otic capsules we have produced microscopic changes which stimulate the histopathological picture of otosclerosis found only in the human ear

Figure 1 illustrates the condition two-and-one-half months after the operative procedure The cautery needle was applied to the anterior footplate and to the anterior crus Considerable spread of coagulation over the upper posterior part of the middle ear was given to blanch and destroy the mucosa of the middle ear

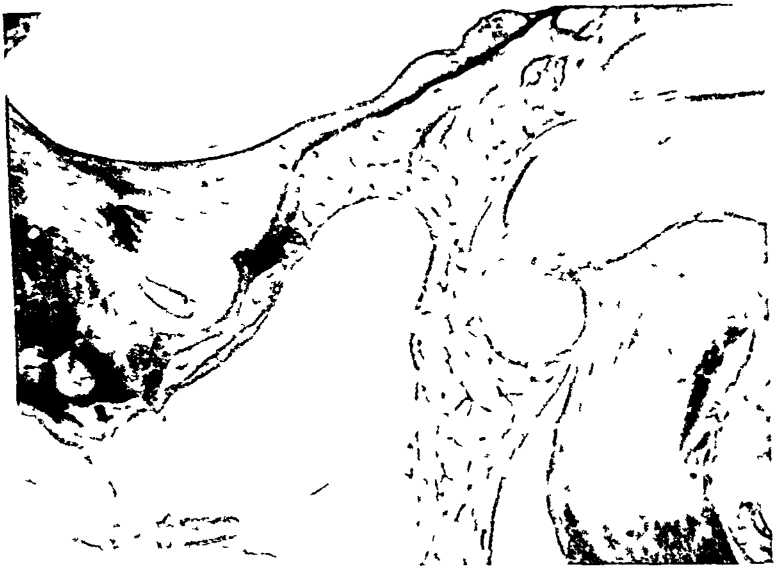

Fig 1 Cat No 16 Aut 157 sec 124 left Postoperative time 2½ months Ankylosis of the greatly thickened footplate is evident anteriorly The fragile crura have been completely replaced by fibrous tissue A charred mass (bone ash?) lies in the area Arising from a hypervascular submucosa vessels enter the footplate and a widened vascular channel in the otic capsule posterior to oval window Anterior to oval window a widened vascular channel appears surrounded by a counterstained area which simulates blue mantling' in human otosclerosis

A postoperative note states that on the third day after the operation this cat was able to jump up on the table voluntarily and come down from the table normally

The microscopic section reveals that no crura of the stapes are present The footplate is firmly ankylosed anteriorly

Within the otic capsule, both anterior to the oval window and posterior to it, there is an enlarged vascular channel with metachromatically stained bone surrounding the canal No otitis media nor purulent labyrinthitis is present In the dense fibrous tissue filling in the oval window niche in response to the trauma, a mass of charred particles is seen This probably is the charred bone ash of the crura

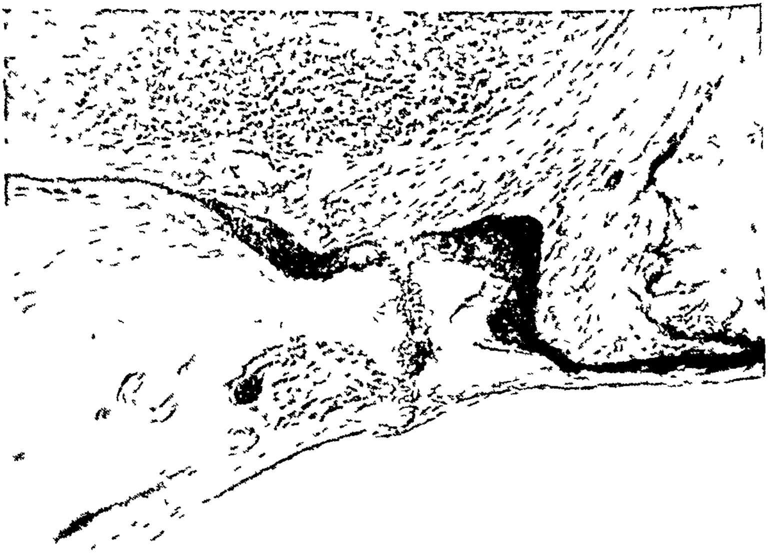

Fig 2 Cat No 13 Aut 184 sec 94 right Postoperative time 3 months 5 days Again we see ankylosis of the footplate and fibrous replacement of the crura Anterior to the joint is a widened vascular channel lined with osteoblasts

The organ of Corti exhibits a mound of cells of the usual contour and height throughout the cochlea Outer and inner hair cells appear to have been disrupted in the lower coils and exhibit more nuclei than normal Hensen's cells and the sustentacular, or Deiter's cells, show marked changes, the latter having lost their cytoplasmic membranes in the basal turn Perhaps the excessive number of nuclei among hair cells is really due to displaced nuclei from the sustentacular cells The apical organ is more nearly normal except for the sustentacular cell of the inner hair cell Reissner's membrane and tectorium are *in situ* throughout The latter is slightly lifted from the limbus Spiral ganglion cells appear normal but show a tendency to have the nucleus in the proximal end of the cell There is hypertrophy of the tympanic nerve

Figure 2 illustrates a similar condition with obvious ankylosis of the stapes and fibrotic replacement of the crura Within the otic capsular wall an enlarged vascular area is seen, with the central region traversed by fibroblasts and the bony wall lined with osteoblasts

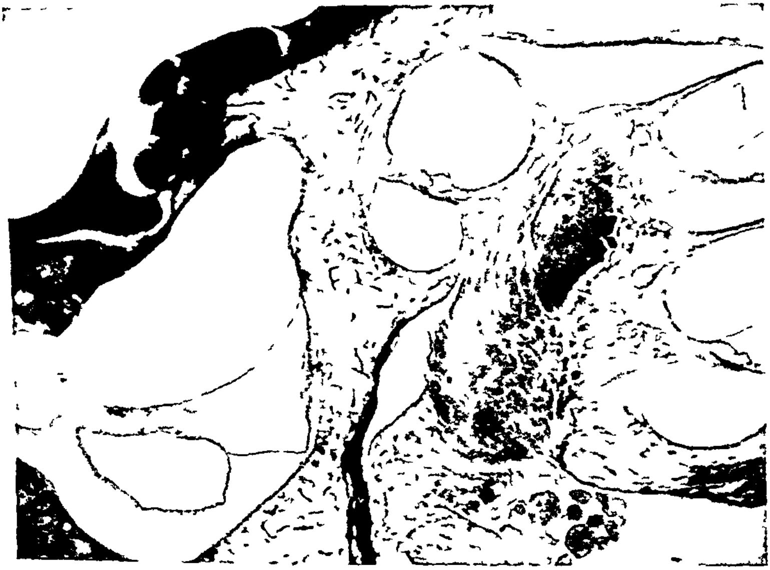

Fig 3-a Cat No 14 Aut 171 sec 280 left Postoperative time 5½ months Ankylosis is present both anteriorly and posteriorly The footplate is thickened only near the ankylosed regions Widened vascular channels with perivascular fibrosis occur both anterior and posterior to the oval window A lympnadenitis was present in this ear

The operative note in this case states that the cautery was applied in light amount to the footplate and to the anterior crus, also to the incudostapedial joint The incudostapedial joint area has been completely replaced by fibrous tissue, as have the distal parts of the crura Some evidence of the proximal parts of the crura remain at other levels than the one photographed The organ of Corti presents the same microscopic picture as the preceding case with the exception that Reissner's membrane is frayed and disrupted in one specific region in the middle coil, yet remains taut and *in situ*

Figure 3-a presents a third case in which ankylosis has occurred both anteriorly and posteriorly At these two areas the footplate is thickened Widened vascular channels can be seen in the wall of the otic capsule, both anterior and posterior to the oval window

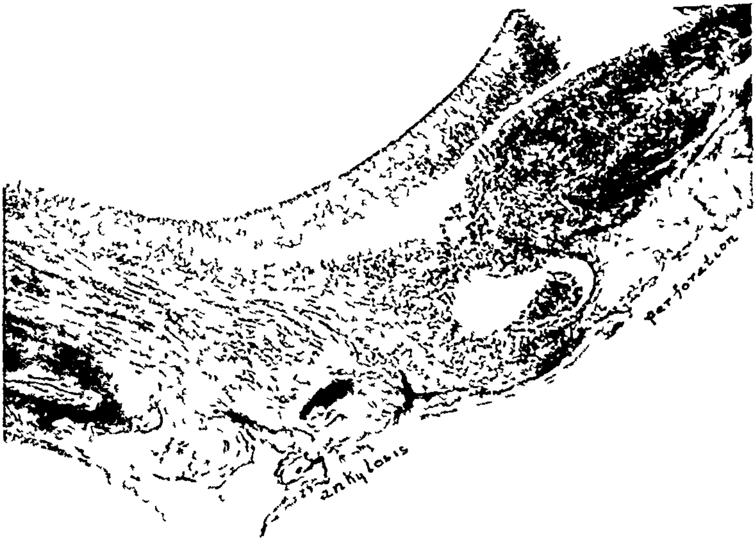

Fig 3-b Detail of the footplate of Cat No 14 Aut 171 sec 260 This shows the area of perforation of the footplate No bone covered this perforated area Therefore this footplate was not physiologically ankylosed

The operative note on this ear states that the incus and crura were removed A small perforation was made in the footplate This perforated area did not close with anything but fibrous tissue, although this animal lived five-and-a-half months after the operation Figure 3-b shows the persistent perforation This stapes was, therefore, not physiologically ankylosed

The cochlea in this case presents an organ of Corti of normal contour, but the structure definitely appears coagulated

Spiral ligament of the lower basal turn is devoid of fibroblasts and connective tissue Reissner's membrane sags over the limbus throughout, however, the spiral ganglion cells appear normal

Figure 4 shows a detail of the peculiar and specific vascular reaction which this treatment seems to engender in the

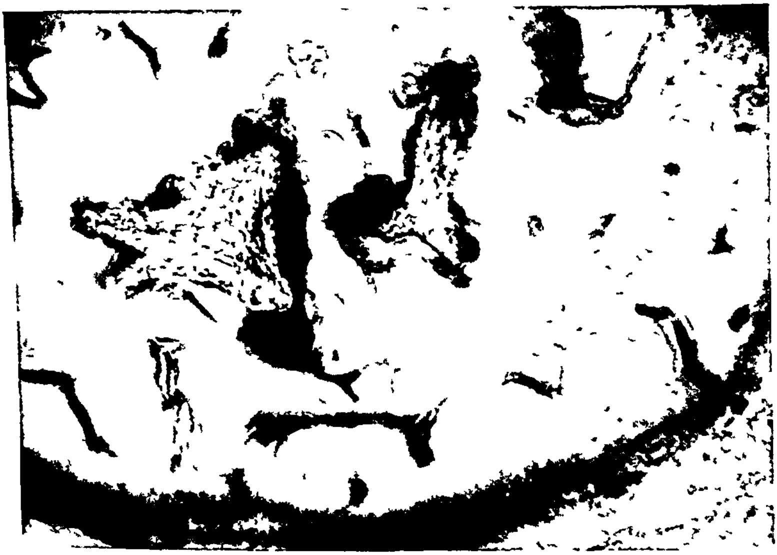

Fig 4 Cat No 16 Aut 157 sec 95 right Postoperative time 3¼ months Detail from the promontory showing metachromatic staining of bone around widening vascular channels The left center field presents a picture similar to halisteresis In other areas osteocytes are being set free by as yet unknown decalcifying processes The freed cells are then converted either into fibroblasts osteoblasts or osteoclasts

otic capsule A "blush" of purplish-red dye surrounds some of the vascular channels, while others remain normal in appearance In these pathological areas decalcification has either already occurred or seems imminent Clear areas along the border of the lesion suggest halisteresis In these regions several osteocytes, recently freed from their lacunae, appear to congregate and form osteoclasts These are really giant cells of the foreign body type Their function must be to phagocytize fragments of the decalcified bone rather than to break it down, themselves This seems to be the case, since that Reissner's membrane is frayed and disrupted in one specific region in the middle coil, yet remains taut and *in situ*

Figure 3-a presents a third case in which ankylosis has occurred both anteriorly and posteriorly At these two areas the footplate is thickened Widened vascular channels can be seen in the wall of the otic capsule, both anterior and posterior to the oval window

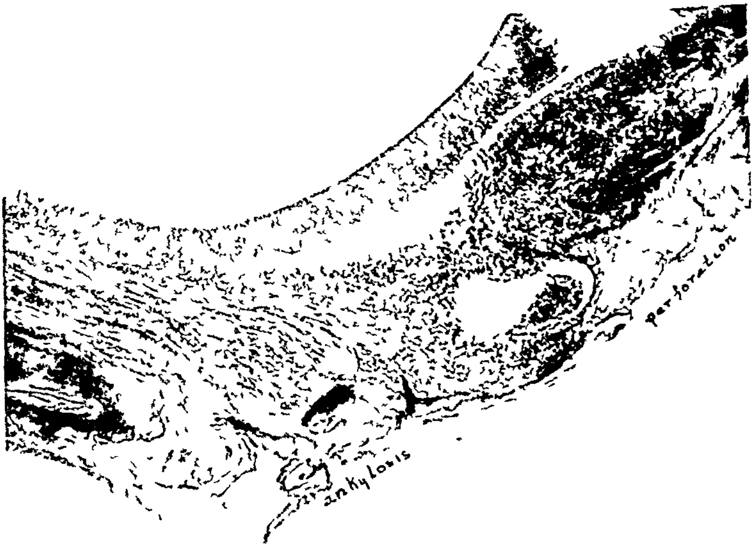

Fig 3-b Detail of the footplate of Cat No 14 Aut 171, sec 260 This shows the area of perforation of the footplate No bone covered this perforated area Therefore this footplate was not physiologically ankylosed

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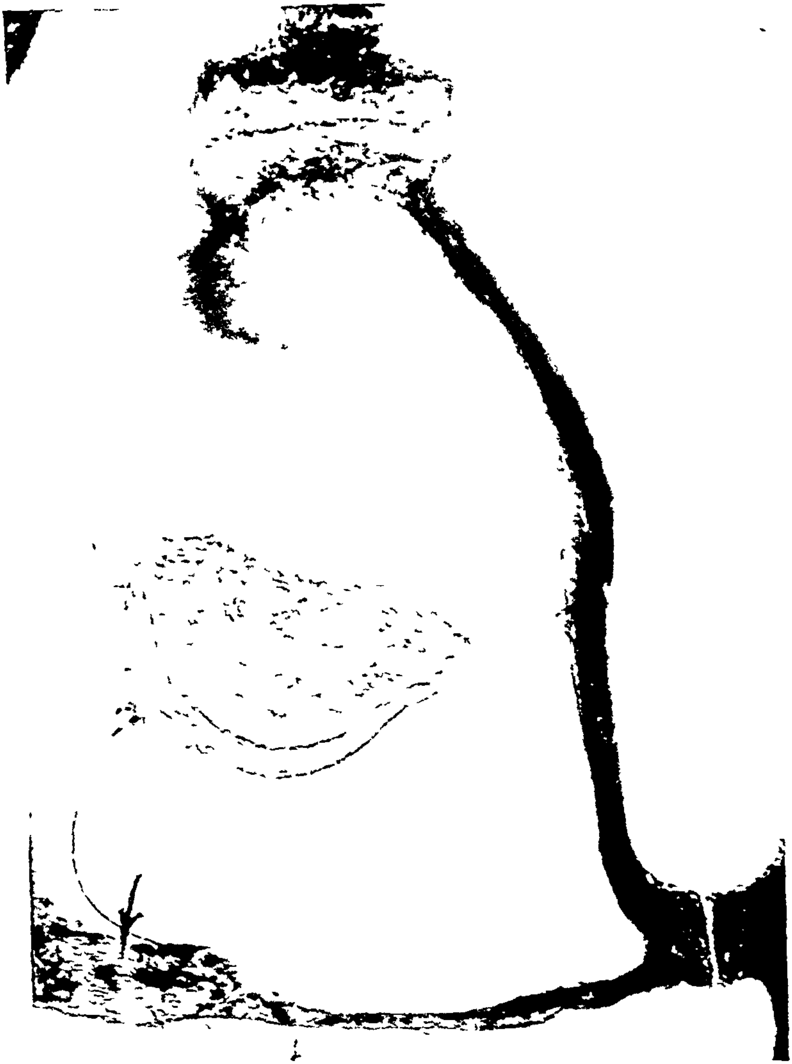

Fig 6-a Ankylosis of footplate of stapes in a rat fed Lathyrus odorata by Dr Lalich (University of Wisconsin) The head of the animal was processed in our laboratory at our request to see if any evidence of stapedial ankylosis could be found in cases of nutritional disturbances

Figure 5 illustrates a condition in another promontory. This was present six months and nine days after exposure to the cautery needle The longitudinal section of the vessel shows the widened vascular channel with the surrounding the clear halo with decalcification appears before the osteoclasts have actually formed

Other freed osteocytes become converted into fibroblasts, filling up the space between vessel walls and bony walls When the decalcification process has gone "far enough," i e, presumably to supply physiological local demands, osteocytes

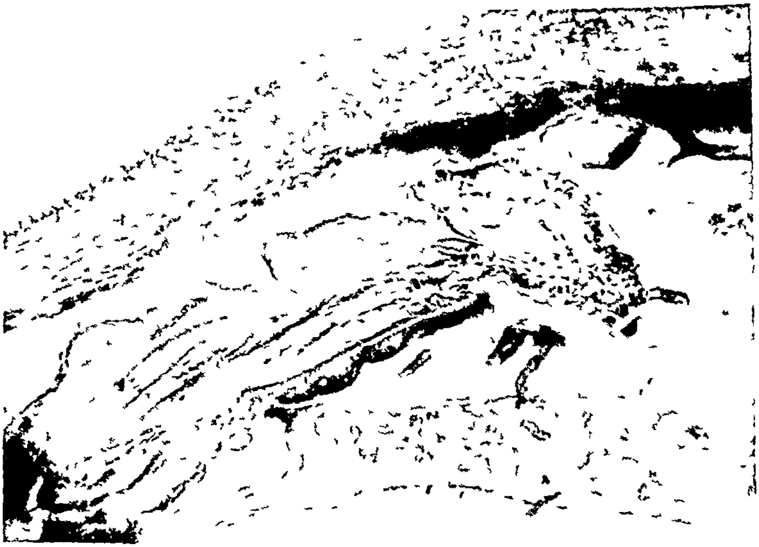

Fig 5 Cat No 12 Aut 175 sec 199 right Postoperative time 6 months 9 days Detail from another promontory showing widened vascular channels The similarity to blue mantling' in otosclerosis is striking in the longitudinal cut of the vascular channel Fibrotic replacement of bone has occurred in the irregular cross section above and to the right

will then be converted to osteoblasts and start regenerating bone

In the lower left field of Figure 4 we see the initial stage of the development of this type of pathological condition A congested blood vessel is seen within the bony channel and on each side of the vessel are clear spaces These spaces undoubtedly are formed by some fluid which has been exuded from the vessel Inferiorly in this same small lesion, the effect of such extrusion upon the bone is evidenced by the elongate lighter spaces in the solid bony field

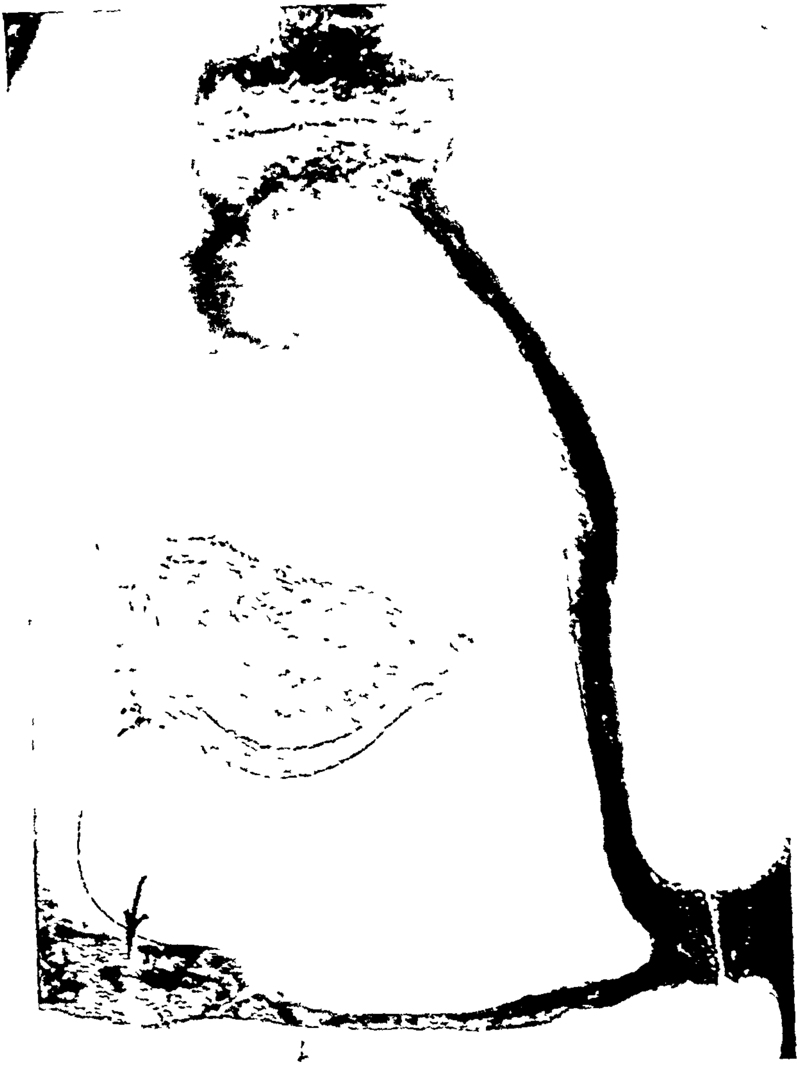

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Figure 5 illustrates a condition in another promontory This was present six months and nine days after exposure to the cautery needle The longitudinal section of the vessel shows the widened vascular channel with the surrounding "blue mantling" which really acts like a chemical indicator, demarcating the pathological from the normal state of the surrounding bone Under very high power the spread of this "indicator" can definitely be traced through the canaliculi[4] In the center field, osteoblasts are forming along the bony wall of the vascular channel To the upper right of center we see an irregular cross sectional area where fibrotic

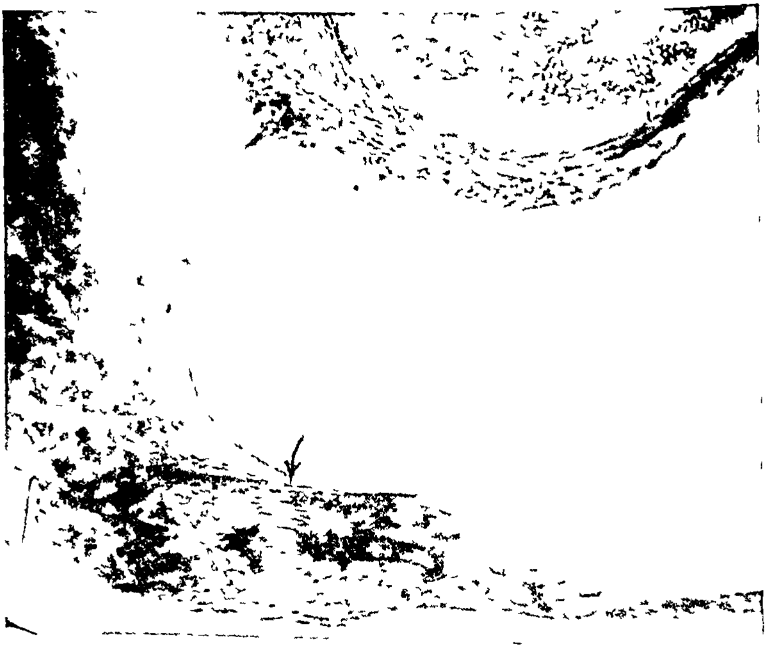

Fig 6-b Detail of calcium bar crossing the stapediovestibular joint space in the rat This pathological calcium deposition is the result of nutritional disturbance No middle ear infection is present The cellular elements are blood corpuscles within the stapedial artery as shown in Fig 6-a This vessel is persistent in rodents

replacement of bone is occurring Here, also, osteoblasts and osteoclasts are developing

These illustrations indicate that we have experimentally produced a lesion in the bony otic capsule of the cat, which simulates closely the histopathological lesion in the human otic capsule in cases clinically diagnosed as otosclerosis

CONCLUSION

Ankylosis of the stapediovestibular joint can be produced experimentally This can be accomplished in one of several ways

1 We have produced ankylosis of the stapediovestibular joint in five of eight possible cats' ears, by the use of electrocoagulation The use of the electric cautery also produced lesions in the otic capsule, which simulate the histopathological picture of human otosclerosis

2 We have produced ankylosis of the stapediovestibular joint by mechanical trauma, as reported at the American Otological Society in California in May, 1958 This was produced in four cats' ears

3 The final illustration shows ankylosis of the stapediovestibular joint in a rat fed excessive doses of lathyrus factor by Dr Lalich, of Wisconsin University At our request we have processed several of the temporal bones of his experimental animals, and those of Iowa University Evidence accumulates in our laboratory to the effect that altered nutrition may cause ankylosis of the stapediovestibular joint Because of the prevalence of otitis media in these animals, we are awaiting publication of this last point until more examples without otitis media can be demonstrated We are also feeding our own guinea pigs ground pea meal (Lathyrus sativa) with encouraging results

The interpretation of our findings will require the investigative skill of a chemist and a biochemist In producing the perivascular lesion in the bone we do not know whether we have an electrochemical effect or merely a thermal effect We may have a true electrolysis of the bone If so, what state of being in human pathology induces this kind of reaction in cases of otosclerosis? The potential lability of bone has been clearly demonstrated previously, but what is the chemistry of the tissue fluid which is able to wash out the bone salt so completely and yet so locally? These are imponderables which await further investigation

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REGRESSION OF HEARING IMPROVEMENT AFTER MOBILIZATION OF STAPES*†

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and
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When stapes mobilization was introduced by Rosen in 1953, some otologists believed that it was not possible to mobilize an ankylosed stapes, others believed that once mobilized the stapes quickly would become fixed again. Since then considerable experience has been gained with this type of surgery, and it now generally is accepted that *most* fixed stapes can be mobilized with a significant improvement in hearing. With the passage of time, however, an impression has been gathering that the improvement in hearing obtained by stapes mobilization undergoes regression to the preoperative level in many cases. This study was undertaken to investigate the frequency and possible responsible factors of this postoperative regression in hearing.

Although the mobilization of the stapes operation has found a place in modern otological surgery, its true value can be established only after the long range benefits to the patient are appreciated. This study, however, is *not* based entirely on cases which have been observed for over very long periods of time. Due to the high percentage of regression which has occurred within the first few months after the operation, we believe it is important to indicate now the trend our cases is taking.

It was believed generally that growth in the otosclerotic lesion was responsible for refixation of the stapes and regression of hearing to the preoperative level. Our observations on

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experimental animals indicated that other factors may play a part in the refixation of the stapes [1,2] In experimental animals mild surgical trauma at the stapedio-vestibular joint, injuring the adjacent stapes and vestibular wall initiated a very active tissue response In this tissue reaction, hypervasculization and fibrosis, as well as the deposition of new bone, were observed In many cases the stapedio-vestibular joint space actually was bridged by new bone and ankylosis of the stapes resulted

It is reasonable to assume that a comparable tissue response could occur in the human, and the trauma induced in the process of mobilizing the stapes could partially be responsible for refixation of the stapes In human surgery it has not been possible to examine the stapes of all cases in which a postoperative regression of hearing occurred, however, in all cases re-operated because there was regression of hearing, the stapes always was found reankylosed

Our technique of mobilization has been modified from that used in the early days, when the mobilizing force was applied only to the neck of the stapes, to one in which the mobilizing force is applied directly to the lesion at the footplate This orderly change in technique permits a convenient division of our cases into two groups In the early group trauma to the footplate was minimal, in the other, some degree of trauma was induced in all cases as the forces for mobilization always were applied directly to the point of maximum fixation at the footplate In this latter group the lesion was visualized with the microscope and classified into four groups according to the anatomic and pathologic findings [3]

It has been noted that a higher percentage of cases had an immediate improvement in hearing when the forces for mobilization were applied directly to the point of fixation at the footplate This apparently is a logical observation, for within any group of cases the otosclerotic lesion varies in extent from a minute area of fixation to a complete replacement of the footplate There is a graduated scale in the size and extent of the otosclerotic lesion Some stapes with a small area of fixation can be mobilized by any technique, in other cases, the otosclerotic lesion is extensive, and our presently used techniques are useless The percentage of good immediate results appears to increase with the amount of pressure that can be applied safely to the stapes, and most pressure can be applied directly at the point of fixation

In the earlier techniques the strength of the crura was the limiting factor in mobilization of the fixed footplate Only cases with small degree of fixation could be mobilized by applying pressure to the head or neck of the stapes The stapedio-vestibular articulation on the other hand, was not traumatized directly in the process of mobilizing the stapes

TABLE I

Unclassified Cases—Force applied to head or neck of stapes
Classified Cases—Force applied directly to footplate at lesion

	Total Cases	No Above 30 db	Per cent	Per cent Regression in 4 Mo	12 Mo	18 Mo
Unclassified Cases	212	102	48	23 5	35 3	39 0
Classified Cases ..	142	85	60	36 0	..	

With the application of force at the head and neck, 48 per cent of the cases obtained an immediate improvement in hearing above the 30 db level Although no direct trauma to the stapedio-vestibular joint was induced in the process of mobilization, 23 5 per cent of cases were found to regress to the preoperative level within four months The high rate of regression continued after this period, as 35 3 per cent had regressed within 12 months and 39 per cent within 18 months (See Table I)

Later cases which have been grouped in four classes according to the anatomic and pathologic findings can be studied in greater detail In this group of cases the mobilizing forces were applied directly to the footplate at the point of maximum fixation, and an immediate improvement in hearing above the 30 db level was obtained in 60 per cent of cases In this group of 142 consecutive cases, an unusually high number of cases happened to be of Class IV Excluding this group of very unfavorable cases for mobilization by our present technique, 76 2 per cent of all others had an immediate improvement in hearing to above the 30 db level In our previous report[3] which included all Class IV cases, 72 per cent had an immediate improvement in hearing Many more cases were mobilized when the force was applied directly to the lesion as the strength of the crura was not a limiting factor More trauma, however, was induced at the footplate of the stapes in mobilizing cases with more extensive lesions With the application of more force at the footplate, more trauma was induced to these structures In the four months following the operation, 36 per cent of those cases which had an immediate improvement in hearing to above the 30 db level regressed to the preoperative level There were too few cases which were observed beyond the four-month period to make a significant report at this time

TABLE II

Regression of Hearing Improvement in Classified Cases Four Months Postoperative

	No of Cases	No Above 30 db	% Cases Improved	Number Regress	Per cent Regress
Class I Early Otosclerosis	26	22	84 6	2	9
Class II Mod Adv Oto	63	43	68	23	53
Class III Adv Otosclerosis	21	16	76	4	25
Class IV Unfavorable Cases	32	4	12	2	50
Totals	142	85	60	31	36

The postoperative behavior of the four classes of otosclerotic involvement can be compared In Class I were grouped cases in which the otosclerotic lesion was small Palpation revealed fixation at one end of the stapes, while the other was free The footplate was blue in color, and there was no narrowing of the stapedio-vestibular joint space The otosclerotic lesion was not visible with the microscope An immediate improvement in hearing was obtained in 84 6 per cent of cases As the otosclerotic fixation was minimal, the mobilization procedure was not traumatic to the tissues at the footplate of the stapes Only 9 per cent of this group showed regression to the preoperative level within four months (see Table II)

In Class II were grouped cases with visible narrowing of the stapedio-vestibular joint space by otosclerosis The footplate was blue in color, but palpation revealed fixation at the involved end, the other end was free The crura were not included in the otosclerotic mass The majority of the 142 cases included in this study presented characteristics of Class II In this class, the otosclerotic mass bridged the articulation and was so extensive that there was visible narrowing of the stapedio-vestibular joint space Considerably more difficulty was encountered in mobilizing the fixed footplate Head or neck application of force usually was not successful, as frequently the crura were fractured Much more trauma occurred at the footplate of the stapes when the mobilizing forces were applied directly to the point of fixation The adjacent vestibular wall, stapes and footplate were traumatized When mobilization was achieved directly through the lesion by division of the otosclerotic mass the fracture permitted the roughened halves of the otosclerotic mass to oppose each other, leaving surfaces readily exposed to the tissue reaction which follows Sixty-eight per cent of cases had an immediate improvement in hearing to above the 30 db level Although this high percentage of cases had an immediate improvement in hearing, the rate of regression was also high, as 53 per cent returned to the preoperative level of hearing within four months (see Table II).

When the otosclerotic lesion was very extensive and involved, one end of the footplate including the adjacent crus, the case was characteristic of Class III Here the footplate was of normal blue color except for the area near the otosclerotic involvement The mobilizing technique had to be altered in this type of case as the lesion was too extensive for mobilization directly through the mass The technique recommended by Fowler[4] is ideally applicable The crurotomy avoids direct fracture through the otosclerotic mass, and the mobilization is made through normal bone with less trauma. Seventy-six per cent of the cases in this group had an immediate improvement in hearing to above the 30 db level Twenty-five per cent returned to the preoperative level of hearing within four months (see Table II)

In Class IV were grouped cases unfavorable for mobilization by our present techniques In most instances, little could be done surgically, as the otosclerotic lesion had replaced the entire footplate or had reduced the oval window niche to a slit In other cases the exposure was very unfavorable or the crura of the stapes were involved so that continuity of the ossicular chain could not be preserved In this study of 142 consecutive cases an unusually large number of unfavorable cases occurred This lowered the general average of good results considerably An immediate improvement in hearing was obtained in only four cases of 32 in Class IV In all four the footplate of the stapes, although completely infiltrated and thickened by otosclerosis, was able to be elevated and separated intact from the vestibule Two of the four cases, however, regressed to the preoperative level within four months

COMMENTS

Regardless of the responsible factors, there is a surprisingly high percentage of cases which regressed to the preoperative level of hearing following the mobilization of the stapes Although the active otosclerotic lesion may cause refixation of a mobilized footplate, evidence from animal experiments and analysis of our cases indicate that the tissue reaction following trauma induced by the mobilization procedure also may play a significant role

This study has revealed that the percentage of regression in hearing following a successful mobilization of the stapes operation is proportional to the degree of trauma induced at the region of the stapedio-vestibular joint space in mobilizing the fixed footplate The application of force to the footplate directly has elevated the percentage of immediate good results to above 70 per cent

The technique of mobilization used in these cases has been conservative, and an attempt has been made to leave the stapedio-vestibular joint space as normal as possible following the mobilization of the stapes Regression in hearing has occurred regardless There are many cases which have maintained hearing above the 30 db level for over three years without any sign of change This, of course, attests to the value of this surgery As the high percentage of regression is a serious problem, our attention should be directed toward improving the technical approach in order to reduce the postoperative regression in the improved hearing

CONCLUSIONS

Of all cases having an immediate improvement in hearing above the 30 db level, 36 per cent were found to regress to the preoperative level within four months This high rate of regression is probably due in part to the refixation of the stapes by an actively growing otosclerotic lesion and in part by the tissue reaction, which occurs as a result of the trauma induced in mobilizing the otosclerotic lesion at the footplate

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THE EIGHTH BRAZILIAN CONGRESS OF OTOLARYNGOLOGY AND BRONCHOESOPHAGOLOGY

The Eighth Brazilian Congress of Otolaryngology and Bronchoesophagology will be held in Porto Alegre, Brazil, the first week of September, 1959 President Dr Ivo A Kuhl, Andradas 1727, Porto Alegre, Brazil

TUMORS OF THE GLOMUS JUGULARIS

A Report of Nine Cases*

J LEWIS DILL, M D ,†
Detroit, Mich

Guild,[1] in 1941, reported the presence of small structures in human temporal bone sections located near or in the wall of the jugular bulb, to which he gave the name "glomus jugulare," and in his paper in 1953,[2] he further discussed these bodies He had noted that they occurred with almost equal frequency along the course of the nerve of Jacobson The number of glomus bodies in an ear varied from possibly none to as many as twelve Of 88 ears studied, 60 had either one, two, three or four glomera each About one-half were found in the adventitia of the dome of the jugular bulb, one-fifth in the osseous canal, through which the nerve of Jacobson enters the middle ear from the jugular fossa, and about one-fourth had a glomus formation in the mucosa of the cochlear promontory as far peripherally as the descending facial canal

Simpson and Dallachy[3] reviewed the reported cases of tumors of the glomus jugularis, and found a total of 172 cases, only 14 of which had been reported prior to 1945 Ages in the 172 cases varied from 22 years to 69 years, and it was noted that the tumor occurred five times more frequently in women than in men These authors state, "Tumors of the glomus jugulare in the middle ear grow slowly, and the constituent cells are uniform in appearance There is no capsule, however, and continuous expansion of the growth occurs with extension outward along the external canal, upwards into the middle cranial fossa, medial with damage to or destruction of the structures of the internal ear and labyrinth, or downwards into the jugular foramen Spread may occur

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in more than one direction. The lesion in the vast majority of recorded cases shows locally invasive characteristics."

They further stated that, "while the site of origin largely determines the direction in which the growth spreads, the cases largely fall into four main clinical groups. Under their Group I classification there are aural symptoms only. In Group II there is neurological involvement developing years after the aural symptoms. The nerves involved by pressure are usually the IXth, Xth, XIth, and XIIth. In Group III the neurological symptoms and aural symptoms develop concurrently. The growth here probably arises near the origin of the tympanic nerve. In Group IV, the least common, the neurological symptoms precede the aural symptoms.

Except for Group IV, of which there were no cases, each of our nine cases fits aptly into one of the foregoing classifications. In Group I, the largest, there were six cases. Of these six, four were Negro, two were white, and sex was equally divided between male and female. Ages ranged from 31 years to 65 years.

A case, a white female, aged 23, came under the Group II category. In Group III, both patients were white, female, and ages 37 and 43 years respectively.

GROUP I

Case 1.—P. G. (024592), female, white, aged 55.

Initial visit Sept. 7, 1949. Complaint of thumping sensation in left ear, noted since preceding November, which was synchronous with the heart beat. There was an occasional pain in the left ear. Examination revealed a redness of the inferior quadrant of the left tympanic membrane. Hearing test showed 15-20 db loss of hearing, left; mastoid X-rays were negative. No diagnosis established.

Return visit May 2, 1951. No treatment since previous examination 20 months previously. Tinnitus was persistent in left ear and an increased sensation of fullness of the left ear had been noted for several months. Examination revealed a reddish mass at the inferior quadrant of the left middle ear; hearing test showed a loss of 30 db in the left. X-rays of mastoid, petrous apex, and base of skull were negative. A tentative diagnosis of glomus jugularis tumor was made; surgery, however, was postponed.

Return visit May 24, 1952. No apparent enlargement of tumor; no particular increase in patient's symptoms; biopsy was done. Pathological report: Glomus jugulare tumor; treatment: X-ray 3000 r units.

Return visit June 16, 1953. Tumor was still present; no progressive enlargement nor increase in symptoms was noted, treatment X-ray, 3000 r units

Yearly observations were made during 1953 to 1958

Last progress visit Sept 17, 1958 Patient had no particular complaints other than a very mild tinnitus in the left ear Examination revealed slight thickening of the left drum, a small red tumor was visible through the drum, apparently arising from the floor of the middle ear This tumor appeared to be smaller than before, hearing remained about the same as before, possibly slightly improved (see Fig 1)

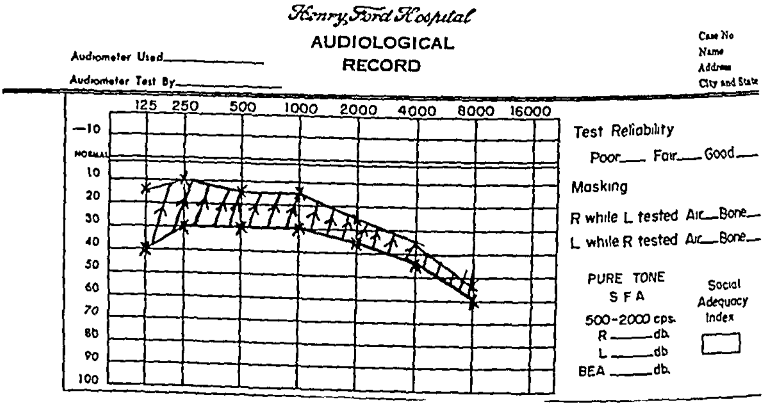

Fig 1 Case 1 No 024592—Hearing tests left ear, 1951 and 1958 Slight improvement of hearing noted

COMMENT After a period of ten years this patient is alive and well with very few symptoms relative to the tumor in the left ear This would not appear to be active and the patient should, in all probability, outlive the growth in her middle ear

Case 2—E K (828721), male, white aged 31

Initial visit April 3, 1956 Complaint of thumping sensation, right ear which had been present about eight months This was continuous and was synchronous with his heart beat Examination revealed a normal right ear drum, with a reddish mass noted in the middle ear arising from the floor of the middle ear, hearing test revealed approximately normal hearing

Surgery April 27, 1956 The tumor was removed through the auditory canal with elevation of the drum, as in the stapes mobilization procedure Considerable bleeding was encountered which was readily controlled Pathological diagnosis Glomus jugulare tumor (see Fig 2)

Last progress visit Sept 11, 1958 Patient was entirely well with no ear symptoms two and a half years following removal of tumor There was no evidence of recurrence of the tumor on examination slight improvement of hearing was noted

Case 3—J A (768230), male Negro aged 32

Initial visit Oct 13, 1954 Complaint of thumping sensation left ear, more marked on lying down, two months in duration, no hearing loss was noted Examination of the left auditory canal revealed a mass or heaped up area in the auditory canal just external to the drum This mass involved the floor of the canal and extended upwards on the posterior wall it was soft to the touch and appeared to be cystic, a mass of red tissue in the middle ear behind the inferior quadrant of the drum was also noted, both seemed to be continuous X rays of mastoid and middle ear appeared normal, audiogram showed apparently normal hearing Biopsy was taken from floor of canal, there was slight bleeding Pathological diagnosis Glomus jugulare tumor

As patient was from out of town X-ray therapy was given by his local physician, this apparently had no effect on the tumor, and the patient became increasingly aware of his heart beat and felt that the thumping sensation was likewise increasing

Feb 22 1955, four weeks since X ray therapy No change in size of tumor thumping sensation left ear, increased

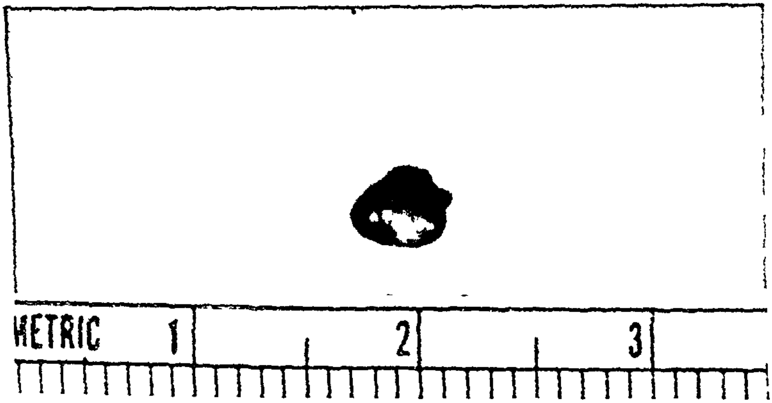

Fig 2 Case 2 No 828721—Photograph of tumor (encapsulated) removed from middle ear

Progress visit July 2 1955 There appeared to be some enlargement of the tumor

Surgery July 12 1955 Radical mastoidectomy was done, the tumor was removed and no excessive bleeding was encountered recovery was uneventful

No evidence of recurrence of tumor in left ear or mastoid on Dec 30 1957 Cavity well healed, audiogram showed a loss of hearing (see Fig 3)

Last contact November, 1958 Patient has remained well with no tinnitus and no symptoms other than a hearing loss This contact by letter was four years after initial visit

Case 4—E K (673952), female, Negro, aged 65

Initial visit March 22 1952 Patient was first treated in the Emergency Room because of severe epistaxis, the episodes of epistaxis had been recurrent over a three-year period, and were attributed to her known hypertension Her past history indicated that in 1926 she had noted a "buzzing and bubbling' sensation in the left ear followed by pain Paracentesis of the left drum resulted in considerable bleeding and the ear had continued to discharge Since 1945 a progressive weakness of the left side of the face had been noted Because of her ear symptoms and findings, she was referred to the Otological Division and seen on the same day Examination revealed swelling of the left mastoid, pinna and preauricular area and purulent discharge in the left auditory canal Tumor growth was seen filling the auditory canal, there was complete paralysis of the left side of the face Chest X rays were negative, mastoid films revealed that "Left mastoid shows sclerotic changes visible in all portions of the mastoid area, no actual bone destruction The diameter of the left auditory canal is much smaller than on the right, does not look like bone tumor "

Surgery, April 1, 1952 Mastoidectomy was done on the left, the mastoid cortex was intact, but bled very freely, the mastoid cells were destroyed and filled with a reddish, infected tumor mass, there was complete destruction of the mastoid and bony ear canal with extension of the tumor into the parotid gland anteriorly The middle ear was filled with tumor mass because of bleeding, the tumor could be only partially removed Pathological report Glomus jugulare tumor On examination of the nasopharynx, we discovered that this tumor was protruding from the orifice of the Eustachian tube

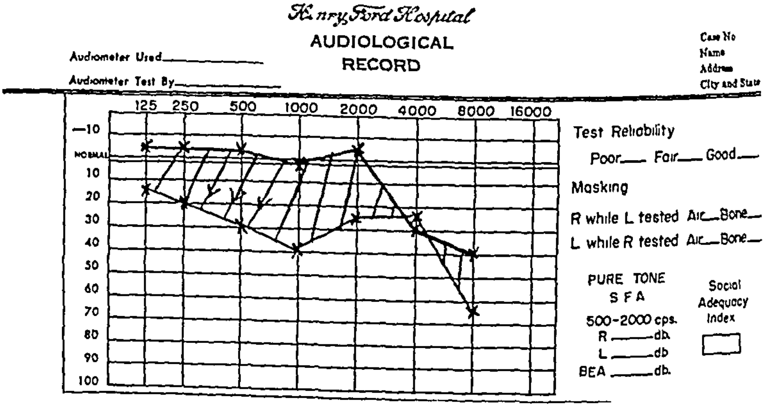

Fig 3 Case 3 No 768230—Initial and final hearing test left ear reveals a loss of hearing

On April 8, 1952, patient was discharged from the hospital with a well healed incision X ray therapy was advised, but the patient refused further treatment, and we have had no further contact since that time

Comment This is a patient with a slow growing glomus jugulare tumor, which remained localized to ear and surrounding tissues, symptoms were reported to extend over a 26 year period, with a facial paralysis of seven years' duration We presume patient is dead

Case 5—M B (834046), female, Negro, aged 60

Initial visit June 12, 1956 Complaint of impaired hearing in right ear, hearing loss had been noted since 1937, there had been no pain or tinnitus Examination revealed a redness of the lower half of the right drum, suggestive of a mass in the middle ear Audiogram showed an air conduction loss for all tones in the right ear and a bone conduction loss for the high tones in the right ear Chest X-ray was negative, mastoid X ray showed normal development and aeration of the mastoid cells with no destruction

Surgery, June 12, 1956 Under general anesthesia, the tumor was removed through the auditory canal The drum was elevated as in the stapes mobilization operation profuse bleeding was encountered After removal of the tumor, the ear drum was replaced in its normal position and the auditory canal was packed Pathological report Paraganglioma or glomus jugulare tumor

Progress visit Sept 4 1956 Perforation of right drum noted, no tumor noted, complains of marked tinnitus in right ear

Last contact in November, 1958 Patient reported by letter that tinnitus was still present, hearing has been unchanged No report of recurrence of tumor

Case 6—J D (903415), male, Negro physician aged 40

Initial visit Feb 3 1958 Complaint of impairment of hearing 20 years, left ear, with pulsating sensation and high pitched tinnitus in that ear Following a paracentesis of the left drum in 1954, the ear had drained for two years but has since remained dry Patient was concerned about possibility of carcinoma left ear Examination revealed a large bluish mass which appeared to be protruding from the inferior three fourths of the left drum Audiogram revealed a combined deafness of approximately 70 db

Examination under general anesthesia Feb 5 1958 On examination the cyst ruptured it had appeared to be a large bluish cystic structure which seemed attached to the floor of the canal in the region near the annulus, and which contained a brownish fluid After opening the cyst wall, there was noted lying within and beneath a bluish red, friable and extremely vascular soft tissue mass, biopsy was taken Pathological report Glomus jugulare tumor

Treatment Feb 10th to March 13th 1958, X-ray therapy, 4000 *r*

Progress visit April 2 1958 Vestibular function was markedly diminished, left ear

Surgery April 30, 1958 Radical mastoidectomy, left was done revealing a large pneumatic mastoid There was tumor filling the entire middle ear and extending into the Eustachian orifice, the epitympanum and the mastoid antrum This tumor was completely removed, except for vestiges over the jugular bulb and carotid artery

Progress visit June 26 1958 Mastoid cavity and ear looked clean, audiogram showed 80 90 db hearing loss (see Fig 6)

Progress visit Sept 4 1958 Ear dry skin graft healed No recurrence of tumor

COMMENT Seven months after surgery the mastoid is clean and there is no evidence of recurrence

GROUP II

Case 7—I B (524432, female, white, aged 23

Initial visit Nov 10 1947 Complaint of pain around right ear for previous three weeks, cough and loss of 14 pounds of weight in the previous six weeks and of having "generally felt bad all over ' for two years History revealed that she had had a plugged up sensation in the right ear, which had begun during a pregnancy five years earlier Two years previously she had had an acute infection of the right ear and since, has had an occasional discharge, general physical examination was essentially negative The auditory canal on the right was clean, but the drum was red and appeared swollen in its posterior quadrant, with a heaped up area along the canal floor close to the drum Mastoid X-rays were negative Biopsy was done and was reported as showing squamous cell papilloma On treatment as an infection, her pain disappeared and there was much less discomfort

Next progress visit 15 months later Complaints were concerning her throat, primarily an inability to swallow for three days Examination revealed a jugular foramen syndrome, with involvement of the IXth, Xth, and XIIth cranial nerves The right ear drum was red, and there was a reddish heaped up area on the floor of the canal against the drum, which appeared papillomatous X rays revealed slight hazing of the right mastoid, the base of skull was negative, the petrous ridges were smooth in appearance, and there was no evidence of destruction

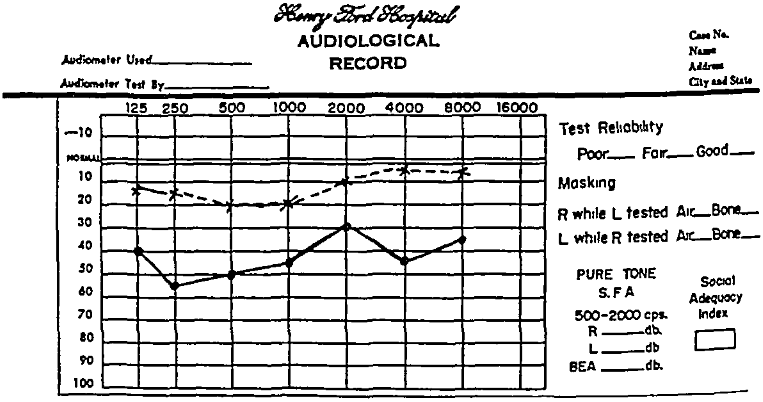

Fig 4 Case 7, No 524432—Mild hearing loss 20 db, left ear conductive loss Right ear hearing loss of approximately 40 db conductive loss

Progress visit Feb 21, 1949 Audiogram revealed approximately 40 db loss of hearing, right ear (see Fig 4)

Surgery Feb 23, 1949 A radical mastoidectomy was done on the right The cortex was removed, and serous discharge pulsated from the mastoid cells The cell walls appeared soft but were intact, there was a reddish tumor mass in the middle ear projecting from the floor of the middle ear and extending into the region of the jugular bulb (This was removed as far as possible)

Pathological report Glomus jugulare tumor

Surgery, May 21, 1949 Right mastoid was reopened The floor of the auditory canal and middle ear was removed, the facial nerve was isolated and the tumor exposed, this could not be removed because, despite pinching off the carotid, there was such profuse bleeding The patient developed a facial paralysis and a left hemiplegia

Treatment Aug 5, 1949 X ray therapy, 2000 r right ear and mastoid

Patient was seen at regular intervals during 1949 to 1954 The facial paralysis improved, as did the left hemiplegia although there was not complete recovery from the latter

On March 31, 1954, X-rays of the mastoid region revealed a progressive destruction of the mastoid and adjacent bone Treatment Cobalt therapy, 4000 *r*

Last contact May 6, 1958 Patient alive and fairly well some evidence of right facial weakness and left hemiplagia remained Mastoid was well healed, no evidence of tumor in mastoid or middle ear, still suspect presence of intracranial progression, but no definite evidence to support this

GROUP III

Case 8—T K (727175), female, white, aged 37

Initial visit Aug 26, 1953 Complaint was of hoarseness, however, history elicited the following In June, 1952, following a tonsillectomy, she noted increasing hoarseness with associated poor appetite In November, 1952 difficulty in swallowing developed, though there was no regurgitation There also was noted a weakness and pain in the left shoulder At the same time, there was noted a throbbing and pounding in the left ear Examination revealed an area of marked redness in the inferior quadrant of the left drum Audiogram showed a conductive deafness of approximately 15 db in the left ear Caloric test was normal in each ear Neurological examination disclosed a paralysis of IXth, Xth, XIth and XIIth cranial nerves A tentative diagnosis of glomus jugulare tumor was made

Treatment Nov 21, 1953 X ray therapy, 2400 *r*, over a three week period

Patient has been followed at intervals from 1953 to 1958 She has shown a definite decrease in her neurological symptoms without the development of any new symptoms

Progress visit Feb 12, 1958 There was still slight deviation of tongue to the left. Voice had improved

On Sept 30, 1958, patient felt her voice was good Solid foods were swallowed without difficulty, although there was an occasional slight difficulty with fluids On examination, a small pinkish blush was noted behind the left drum inferiorly, so small as to be easily missed The tongue still protruded slightly to the left and atrophy of the left side was still present Movement of the soft palate seemed normal, there was fixation of the left vocal cord and arytenoid Audiogram revealed a slight improvement in hearing

COMMENT No biopsy was taken, so the tentative diagnosis of glomus jugulare tumor was never substantiated X-ray therapy seems to have arrested the growth This patient has been under observation for more than five years

Case 9—E K (680217), female white, aged 43

Initial visit May 28 1952 Seen by Division of Neurosurgery Complaint of severe throbbing headache, worse on the left continuous and aggravated by turning head to the left Had associated aching pain in the left shoulder and neck vague in onset, but present six to eleven weeks, deafness and a pounding noise in the left ear had been noted at about the same time Weight loss of 10 pounds associated with anorexia, had occurred in previous four weeks Neurological examination revealed mild papilledema no nystagmus There was minimal left facial weakness atrophy of left side of tongue, protrusion of the tongue since, has had an occasional discharge, general physical examination was essentially negative The auditory canal on the right was clean, but the drum was red and appeared swollen in its posterior quadrant, with a heaped up area along the canal floor close to the drum Mastoid X rays were negative Biopsy was done and was reported as showing squamous cell papilloma On treatment as an infection, her pain disappeared and there was much less discomfort

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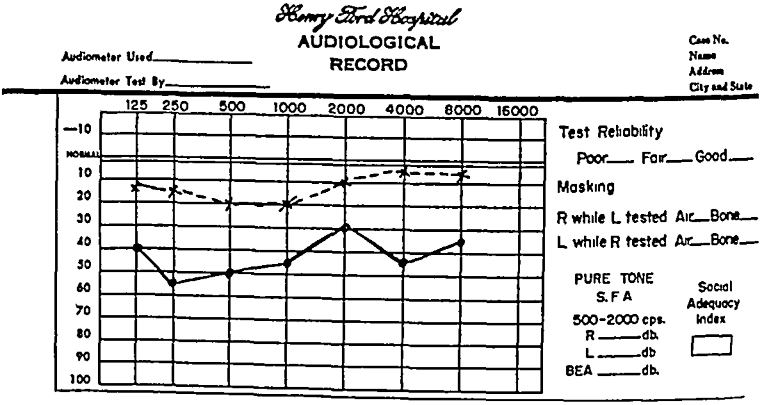

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Our otological consultation elicited a history of tinnitus and deafness, left, for approximately five months Examination revealed an intact left tympanic membrane, which was discolored, and with a peculiar fullness noted in the upper and posterior quadrants, audiogram revealed a bilateral combined deafness of 20 db in the right ear and 55 db in the left (see Fig 5) X ray showed an extensive lytic lesion in the base of the left petrous Impression Tumor, left middle ear, involvement of VIIth, VIIIth, IXth, and XII cranial nerves

Surgery, June 6, 1952 Sub occipital decompression revealed a reddish gelatinous tumor eroding through bone, the tumor infiltrated the petrous and occipital bones, this tumor bled freely A biopsy was taken, ligation of the external carotid and occipital arteries was done, but this did not seem in any way to affect the vascularity of the tumor Pathological report Glomus jugulare tumor Treatment X ray therapy was given over a three week period

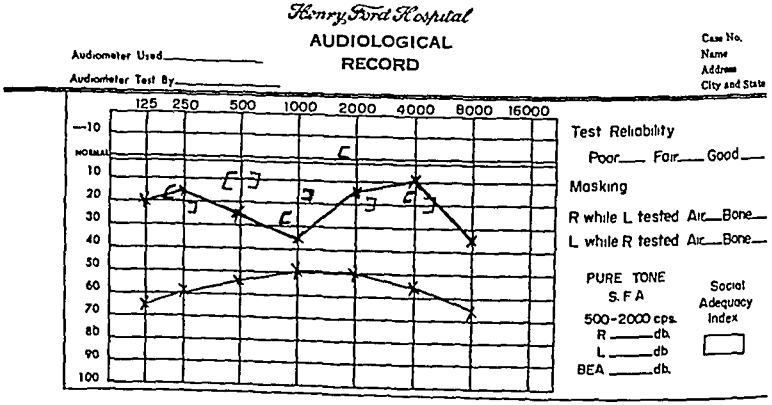

Fig 5 Case 9 No 680217—Combined deafness bilateral More marked loss left ear

Patient's course was gradually down hill There was an increasing enlargement of the tumor in the left middle ear, an increase in the facial paralysis, and increased difficulty in swallowing, which developed from an apparent extension of the tumor around the brain stem A bilateral VIth nerve paralysis also developed in the late stages

Patient expired Jan 9, 1953 No autopsy was obtained

COMMENT This patient was admitted on Neurosurgical service with a cerebellar tumor of apparently short duration There was involvement of the VIIth, VIIIth, IXth, and XIIth cranial nerves, an intracranial operation revealed a glomus jugulare tumor which apparently had extended from the left middle ear

TREATMENT AND RESULTS

Of our nine cases three patients had surgery only

1 *828721, Case 2,* male, white aged 31 Symptoms localized to ear, eight months in duration Tumor of middle ear removed through drum by endaural approach Two and one-half years later, patient is well with no evidence of recurrence

2 *673952, Case 4,* female, Negro, aged 65 Ear symptoms for 26 years Tumor involved mastoid, auditory canal, middle ear, and parotid gland, with extension into Eustachian tube Because of the extent of its growth and the bleeding the tumor could not be entirely removed No further treatment or follow up Patient presumed dead

3 *834046, Case 5,* female, Negro, aged 60 Symptoms limited to ear, 19 years in duration Tumor removed through drum by endaural approach No evidence of tumor recurrence two years later Has perforation of ear drum, persistent tinnitus and nerve deafness

Three patients had a combination of surgery and X ray

1 *768230 Case 3,* male Negro, aged 32 Symptoms two months in duration, limited to the ear No apparent decrease in tumor size as result of X-ray therapy About seven months later, radical mastoidectomy with removal of tumor No symptoms four years later except a hearing loss No evidence of recurrence of the tumor

2 *903215, Case 6,* male Negro aged 40 Symptoms 20 years in duration, limited to the ear X ray therapy given followed about seven weeks later by radical mastoidectomy and removal of growth Nine months postoperatively, there is no evidence of recurrence

3 *524432, Case* 7, female white, aged 23 Symptoms, five years in duration limited to ear at initial visit Fifteen months later, neurological symptoms were present, involving the IXth, Xth and XIIth cranial nerves Radical mastoidectomy with incomplete removal of tumor Mastoid reopened three months later Tumor could not be removed because of excessive bleeding which could not be controlled

Three months later, X ray therapy, 2000 *r*, five years subsequently, X ray therapy, 2700 *r*, one year subsequently, Cobalt therapy, 4000 *r*

Patient alive 11 years later, with no evidence of tumor in ear or mastoid Suspicion of intracranial involvement remains

Two patients were treated with only X ray therapy

1 *024592, Case 1,* female white, aged 55 Seen in 1949 and no diagnosis established diagnosis made three years later , local symptoms in ear of four years' duration

In 1952 X-ray therapy, 3000 r , in 1953, X ray therapy 3000 r

Patient alive and well 10 years after onset very small tumor still present in the middle ear Has a mild tinnitus but no further loss of hearing It is my opinion that this lady, now 65 years of age, with no evidence of progression of the tumor, will outlive her tumor

2 *727175, Case* 8, female, white, aged 37 Neurological symptoms at onset Ten months later when first seen, there was paralysis of IXth Xth XIth, and XIIth cranial nerves Tumor, left ear, with jugular foramen syndrome Normal vestibular test Diagnosis of glomus jugulare plausible No biopsy obtained Diagnosis not proven Patient is definitely improved five years later A small mass very much smaller than it was initially, was noted in the left middle ear Voice is better paralysis still present, slight difficulty in swallowing fluids

One patient on Neurosurgical service had intracranial surgery and X ray therapy

1 *680217, Case 9,* female white aged 43 Admitted on Neurosurgery

with intracranial symptoms History of severe throbbing headache, worse on left Aching pain in left neck and shoulder of six to eleven weeks' duration Deafness and pounding in left ear noted about same time Cerebellar extension of tumor On suboccipital decompression, glomus jugularis tumor found X-ray therapy given, but course was gradually down-hill with enlargement of tumor in the left middle ear, increase in facial paralysis, bilateral VIth nerve paralysis and extension of tumor around brain stem Patient expired approximately six months after initial contact

SUMMARY AND CONCLUSIONS

1 A report is made of nine cases of tumor arising from the glomus jugulare Eight cases have been proven, one case has a presumptive diagnosis because of the location of the tumor in the middle ear and the sequence of symptoms

2 The majority (eight) of these tumors were slow growing, however, one patient with cerebellar symptoms had an apparent rapid onset, and a rapid downhill course (Case 9)

3 In spite of the duration of symptoms in several cases, not one of our cases has been reported as malignant

4 The symptoms produced by these tumors depend on the site of origin and their extension In six patients, the tumor appeared to have its origin in the middle ear, two had neurological and aural symptoms develop at approximately the same time, and one patient developed aural symptoms, followed a few years later with neurological symptoms

5 The duration of symptoms varied considerably The majority had symptoms of rather short duration, however, three patients (all colored) had symptoms of 19 years, 20 years, and 26 years It is of interest to note that these three tumors which had their origin in the middle ear, had only local extension of the tumor into the adjacent areas, and they revealed no evidence of malignancy in spite of their long duration

6 The age of onset (judged from the history) varied from 18 years of age to 51 years of age In seven cases, the symptoms first became apparent in the third and fourth decade, three patients first noted their symptoms at 18 years, 20 years, and 51 years of age, respectively

7 Six patients were female, three were males, a ratio of two females to one male Five of our patients were white, four were colored

8 Five patients with symptoms and tumors limited to the middle ear, who received either surgery, X-ray, or a combination of both, are alive with no evidence of recurrence of their tumor

9 X-ray therapy appeared to be beneficial in our patients but has not eradicated the tumor It seems to shrink the tumor and to lessen the bleeding Two patients who received only X-ray therapy appear to be improved with no evident progression of their symptoms Three patients whose surgery followed X-ray therapy have no evidence of recurrence of their growth

10 Bleeding has not been a serious complication except in two cases At surgery, removal of a rather extensive growth was attempted and produced excessive bleeding with inability to remove the growth entirely in these two patients

11 Of nine patients with a tumor of the glomus jugulare, six are alive and well with no evidence of recurrence of their tumor One patient is alive (has had four pregnancies since onset of her tumor) with no local evidence of recurrence, but there is a suspicion of intracranial extension One patient died of cerebellar extension One patient is presumed dead

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FACIAL PARALYSIS, A METHOD OF TREATMENT WITH MASSIVE DOSES OF HISTAMINE

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Natrona Heights, Pa

The purpose of this paper is to present a preliminary report of the results of treatment of facial paralysis with Histamine Diphosphate by intra-muscular injection of massive doses Twenty cases were treated, 13 cases of Bell's palsy, or idiopathic paralysis, and seven cases of herpes zoster oticus

The generally accepted etiology of the majority of Bell's palsies is an ischemia of the facial nerve near the stylomastoid foramen, caused by arteriospasm These views are held by Kettel[4] and others As a result of this ischemia, various structural changes take place in the facial nerve between the lateral semicircular canal and the stylomastoid foramen

The extent of these alterations depends upon the severity of the interruption of the blood supply The nerve becomes unduly constricted at the stylomastoid foramen and edematous proximal to this point, while tiny hemorrhagic streaks are seen running longitudinally within the sheath The swelling of the nerve within the fallopian canal results in compression of the adjacent blood and lymph vessels, and consequently a vicious circle arises Collier[1] states that a reversible ischemic block may be present for long periods in the nerves of the limbs without leading to permanent change, while the same block occurring in the rigid facial canal will produce increasing vascular stasis and edema leading to complete degeneration She further states that a mixed lesion may occur, some of the axons undergoing degeneration, while others remain in a condition of reversible block and are capable of recovering This is the key to the understanding of the effect of decompression Sullivan[2] also agrees that disturbance of the blood supply is the first cause of this palsy,

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but thinks that the paralysis is a result of the pressure upon the nerve following edema in the rigid canal

Medical treatment includes heat, massage and electrotherapy Drugs with vaso-dilator effects have been used, such as nicotinic acid, intravenous histamine, and papaverine Symphatholytic drugs have also been tried, such as ergotamine tartrate and tetra-ethylammonium chloride Lately, Cortisone has been proposed, and good results were reported by Robbins[4] Cervical sympathetic block has been proposed

Surgical treatment consists of decompression of the nerve Tickle's[7] indications for decompression surgery included *1* cases of acute Bell's palsy that have shown no improvement within two months, *2* cases where recovery is partial and no further improvement shown in two to three months, *3* cases of paresis in which several attacks have occurred causing considerable psychic trauma to the patient Kettel[4] says many authors rely completely upon response to faradic stimulation, claiming that a complete recovery will never occur when the response is negative He says that the majority of his cases showed no recovery after two months of observation and hence indicated surgical intervention Since 75 to 85 per cent of all ischemic facial palsies recover under medical treatment he does not consider any operation at the onset of palsy Kettel also feels that decompression will prevent relapse and recurrence of palsies

As to prognosis, nearly all authors agree that from 75 per cent to 90 per cent of these cases will recover spontaneously Response to faradic stimulation (Tickle[5]) is important and where this response is maintained for two weeks, nearly all cases will recover If no improvement occurs within two months, surgery is indicated Lierle[3] says that in typical Bell's palsy prognosis is good for at least partial recovery in a period of a week to several months, but complete recovery is rare In cases of paralysis of five months' duration or longer, where there has been no improvement of the paralysis one can expect very little improvement after a decompression operation

The second group of cases are those of herpes zoster oticus

FIG 1—BELL'S PALSY

Patient	Onset	Interval to Treatment	Duration Treatment	Symptoms	Treatment Given	Final Result	Return of Function
1 F J, M (35)	12 27 50	2 days	11 days	Paralysis (left), complete, pain and burning	Histamine (IM) 1 10,000, Vitamin B Complex (IV)	Complete function	11 days
2 A C, F (15)	1 29 52	2 days	6 months	Paralysis (right), complete, severe earache at onset	Histamine (IM) 1-10,000	Complete function	6 months
3 L P, M (60)	3 30 52	1 day	3 months	Paralysis (left), complete, severe earache	Histamine (IM) 1 10,000	Complete function	3 months
4 J G, F (40)	9 11 53	2 weeks	1 month	Paralysis (right), severe neuralgia (right) face and ear	Histamine (IM) 1 10,000, Riboflavin 10 mg orally (q i d)	Complete function	1 month
5 T C, M (49)	9 21 54	2 weeks	1 month	Paralysis (right), complete	Histamine (IM) 1 10,000, Vitamin B Complex orally	Complete function	1 month
6 J P (15½)	10 51	3 years	17 months continuously and at 2 month intervals to date	Complete paralysis with pulled face (left), severe headaches	Histamine (IM) 1 10,000, Vit B Comp Tab 1 b i d, patient had headache reactions	Expression normal, Function returned 10%	17 months
7 C H, M (54)	2 17 55	2 weeks	4 months	Paraesthesia anesthesia, pain (right) with complete paralysis	Histamine 1-10,000, sedation	Complete function	1 month

8 F H , F (32)	3½ years prior to treatment, started treatment 6 27 55		2 months	Paralysis complete with some pulling left face	Histamine 1 10,000, patient had severe reaction headache	Complete function	2 months
9 A K , F (50)	2 5 54	2 weeks	2 weeks	Paralysis left complete, pain, burning	Histamine 1 10,000, 3 times weekly for 6 doses	Complete function	2 weeks
10 D W , F (51)	1 2 57	3 weeks	2 months	Paralysis, left, complete with severe pain region Vth and VIIth nerve	Histamine 1 10,000, 1 0 cc daily had already received Vit B, steroids, faradic stim and nerve block—no results	Complete function	4 weeks
11 M O , F (46)	12 10 56	4 weeks	4 months and continues to present	Paralysis complete, right, severe pain, severe edema eyelids	Patient in severe auto accident with development paralysis in 1 wk , nerve block (cervical), Vit B Comp and steroids, no result	90% function	4 weeks
12 G B , F (32)	9 25 57	4 weeks	2 months	Paralysis complete, left	Histamine 0 5 cc increased to 1 0 cc q 3 days	Complete function	4 weeks
13 T S , F (52)	4 12 57	11 days	5 weeks	Paralysis complete, right	Histamine 0 5 cc to 1 0 cc q 3 days	Complete function	7 weeks

According to Gill[7] the disease is an acute involvement of the skin characterized by thick-walled groups of vesicles which may affect the pinna and extend into the external auditory canal, or vice versa. Pain and discomfort are associated with the disease and may precede the vesicles. These vesicles may recede, and scar after an acute phase of seven to ten days. When facial and auricular nerve palsies occur simultaneously, the term Hunt's syndrome is used, the affection is rare. Treatment consists of orthodox lotions, such as ammoniated mercury, boric acid and salicylic acid cleansing of the skin, and pituitrin injections in some cases. Day and Jordan advise that recovery in cases of herpes zoster oticus is rare.

The 20 cases herein presented were treated by intramuscular injection of Histamine Diphosphate (Abbot No. 3286, 2.75 mgm. per cc.) of 1 to 10,000 dilution, using 1.0 cc at daily intervals until return of function began. Then injections were given every two or three days until recovery was complete. Maintenance dose was carried on at one month intervals for the next six months. At that time therapy was discontinued.

Since each case presented rather individual characteristics in symptoms and progress, charts are prepared to cover the entire series. Figure 1 covers all the cases of Bell's palsy. The usual pertinent data as to age, sex, predominant symptoms and interval from onset of symptoms to the time therapy began, is charted. Cases Nos. 1 and 3 were of only several days' duration when seen, and hence the question of spontaneous recovery must always be considered.

Case No. 2 is a high school girl in whom symptoms persisted for six months. Decompression was delayed and intensive treatment continued as outlined above, with complete return of function in six months. Of interest is the fact that this patient became senior queen of her class, following recovery from her paralysis.

It can be assumed that in the remaining cases in which the paralysis was present from one to three months prior to treatment, recovery would probably not occur spontaneously in all cases

One case, No 8, is worthy of special mention, because of the duration of paralysis prior to treatment A 32-year-old female was first seen on June 27, 1955, with left paralysis complete for three and one-half years Treatment was carried on as outlined above, and complete selective nerve function returned after two months' treatment, and has remained functional since then

Another case, No 6, a 15½-year-old male, had paralysis, complete for three years prior to treatment Recovery has been only partial, but the facial contour is good in the "at rest" position without any "pulling" or "drooping" of the face

In summarizing the results of this therapy in 13 cases

1 Duration from onset of symptoms to treatment was from two days to three years

2 Duration of therapy from onset to beginning return of function varied from two weeks to six months

3 One case has not completely recovered after 17 months' treatment

In reviewing the literature, this author was able to find only two cases of Bell's palsy treated in a similar manner Skinner,[11] in his report of 19 cases, treated these two cases with Histamine Diphosphate in a 1/10,000 dilution His remaining 17 cases were treated with 1/10,000,000 dilution of Histamine with good results He expressed a preference for the low dosage therapy

The only other reference to treatment with histamine was by Loomis,[10] who used it by intravenous injection in five cases, all with good results

In Figure II are included seven cases of herpes zoster oticus All presented symptoms of severe pain, vesicles and other sensory losses such as sense of smell Interestingly, six of the seven were females Under treatment by the same methods, recovery was uniformly good in all cases, even

FIG 2—HERPES ZOSTER OTICUS

Patient	Onset	Interval to Treatment	Duration Treatment	Symptoms	Treatment Given	Final Result	Treatment to Cure
14 H J , F (33)	9 5 49	3 days (9 8 49)	7 months	Vesicles (AD), severe pain, weeping ear	Hist 1 1 million Penicillin (IM) Lextron Cap Niacin 50 mgm (severe reaction)	90% function	3½ months
15 F H , F (41)	2 28 51	3 weeks (3 22 51)	1 year reg , infrequent checkups with booster since	Vesicles (AS), severe pain	Hist 1-1 million 1-100,000 1-10,000 Ref Dr Day, Dr Jordan	90% function with "lag"	6 months
16 M G , F (40)	11-27 52	2 weeks (12-11-52)	4 months with return checkup and booster	Vesicle (AS) lip, shingles left body	Hist 1-10,000 later tonsillectomy and dental ext	Complte function	3 months
17 E S , F (64)	12 27 54	1 week	5 months	Severe shingles left forehead, left ear, left face and weeping, severe pain	Hist 1-10,000, Aureomycin Oint sedation, cath Eust tube later	Complete recovery paralysis and mod scar face, ear lobe	2 months
18 C S , F (62)	12 23 55	10 days (1 3 56)	6 weeks	Vesicles (AS) complete, severe pain, loss of smell, mult perforations, entire drum denuded	Hist 1-10,000, sedation, (severe reaction)	Complete function	2 weeks
19 M K B , F (23)	1 24 56	3 weeks	4 weeks	Severe pain ear, rt vesicles, ear lobe and face burning, paralysis complete, right	Hist 1-10,000 daily, Aureomycin Oint to face	Complete function	4 weeks
20 G R , M (45)	6 20 56	4 weeks	3 months	Paralysis complete left vesicles, ear lobe drum and canal left sudden pain	Hist 1 10,000 daily	Complete function	4 weeks

though scarring persisted in the external auditory canal and face in case No 17 Since most authors agree that despite meager literature on the matter, prognosis is very grave in such cases under present methods of therapy, perhaps histamine offers its greatest usefulness in herpes zoster oticus

In conclusion, 20 cases of facial paralysis have been reviewed under therapy with histamine by intramuscular injections in massive dosage Return of function has been uniformly good in a short period of time In none of these cases did any disturbing side effects or complications arise from the drug administered

Histamine in massive doses offers a rapid and simple method of treatment for Bell's palsy and herpes zoster oticus

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IVALON AS A NASAL SEPTAL IMPLANT*

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Experimental and clinical evidence indicates that living autogenous cartilage grafts are preferable to preserved isogenous cartilage when used to correct nasal deformities[1] A third and least desirable choice is to utilize a non-absorbable foreign substance in rebuilding the nose, however, a search for a suitable substance is justifiable if the end-results outweigh the hazards involved when such material is implanted in living tissue, in this instance, the nose[2] When such substances are utilized, the clinician should make a careful study of what happens to the material in the nose, how living tissue reacts to such an implant in that anatomical location, and the functional and cosmetic results attained He is further obligated to report his findings in order to further enhance our knowledge in this important phase of nasal reconstructive surgery This is a report of such a study made on seven cases in which Ivalon (Polyvinyl) sponge was utilized as a nasal septal implant

Two problems encountered in nasal septal surgery prompted this study One deals with the question of the need for replacing the cartilaginous and bony components of the septum removed during the course of a submucous resection Many operations have been devised to preserve as much of these structures as possible[3] We endeavor to employ such procedures when feasible, but situations do arise, when most of the cartilaginous and portions of the bony septum have to be sacrificed A suitable implant must be inserted to strengthen the septum, prevent cicatricial contraction, maintain the stability of the external nose, and to eliminate the "sail flapping" effect that occasionally occurs when only mucous membrane comprises the septum[4,5] The second problem concerns the

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prevention of septal perforations following surgery It is a complication which is a constant annoyance to the patient because of crusting, excessive drying, bleeding and occasional voice changes which may occur Closure of such perforations is difficult[6] Perforations occur in spite of the most meticulous technique Atrophic mucous membrane, marked deformity of the septum, drying and crusting due to abnormal course of air currents, and trauma to the septum from repeated cauterizations can create situations in which perforations are inevitable Should a perforation occur, the operator must provide a bed upon which the mucous membrane can grow, otherwise the healing membranes on each side will meet and a permanent perforation result

The answer to the two problems may lie in the procurement of suitable material to use as septal implants Autogenous and isogenous septal cartilage grafts are the most desirable We have a cartilage bank for preserving cartilage removed at operation, but the segments are too small to serve as a septal implant for the purposes outlined Autopsy material is difficult to procure, and the specimens removed are not much better than the material obtained at operation We were attracted by the work being done by Dr John J Kralik, head of the Department of Cardiovascular Surgery at Marymount Hospital, on the use of Ivalon sponge in experimental cardiac surgery on dogs, and in its use in the human heart After studying his results, we decided to use the material as a nasal septal implant We found in the literature scant references to the use of Ivalon in nasal surgery[2, 7, 8, 9]

Ivalon surgical sponge is a white polyvinyl alcohol sponge made by treating foamed polyvinyl alcohol with formaldehyde[10] The result is a fine-textured white sponge which is soft and resilient when wet, and hard when dry If remoistened, it regains its original softness It can be easily cut with scissors or a sharp knife It can be sterilized by boiling in water and autoclaving On heating in water some permanent shrinkage does occur, but once having shrunk further shrinkage does not occur on resterilization It has been shown that when introduced into the body, the body fluids enter the sponge, and fibroblasts and blood vessels grow into it In reality the Ivalon sponge acts as a framework for living tissue It is claimed that a foreign body reaction does not take place, and no untoward complications had occurred in laboratory animals

We prepared Ivalon for use in the nose in the same manner as for the use in dog experiments and in human hearts, since no untoward reactions have been observed when the material had been treated in this fashion A suitable segment was cut from the block, thoroughly rinsed in sterile distilled water, then compressed in a metal form consisting of two plates held together by four thumb screws The metal compressor containing the Ivalon was then sterilized in an autoclave for one half hour at 250° The Ivalon segment was then removed from the compressor and packed in a cloth and resterilized, then stored for future use If stored for over 30 days, the pack was again resterilized before being used If Ivalon was needed in the course of an operation, it was first moistened in sterile saline, then cut and trimmed to the desired shape After moistening, the average thickness of the segment was 2 mm Care was exercised in inserting the material to be sure no cartilaginous deflections or bony ridges remained, which would cause buckling or displacement of the implant A prominent anterior nasal spine was usually the most troublesome Whenever possible we tried to avoid a transfixion incision in order to have one side of the septum intact, for experience had shown that the line of incision was the avenue of escape for the implant if it was extruded We likewise attempted to maintain the integrity of the membranous septum, for we believe that its proper function is important in facial expression Vaseline packing was routinely inserted in both sides of the nose In dealing with septal perforations we found that drying by inspired and expired air was a factor in healing The longer the packing could be kept in the nose, (up to seven or eight days in some cases), the more likely would healing of the perforation occur We differed in one respect from the procedure followed in cardiac surgery, in that antibiotics were not routinely administered pre and postoperatively The latter cases were considered as infected when the Ivalon was inserted into the heart, and large doses of Penicillin were given in each case Since, as will be discussed later, we did not feel that infection was the chief cause of complications, we saw no justification for using antibiotics as a routine procedure

The number of cases was small, but these were carefully studied and observed almost daily during the initial period following the operation The longest period of observation has been two years and three months, and the shortest period has been two weeks The number was small because Ivalon was implanted only in those cases where extensive portions of the bony and cartilaginous septum had to be removed and could not be replaced or transposed because of marked deformity, and in those cases where through and through tears had occurred during the course of the operation, and the complication of a permanent perforation was feared We did not wish to use a foreign substance in the human nose, about whose reaction we knew little, without justification for doing so Prior animal experimentation, using Ivalon implants in the nose had not been feasible Direct observation of the effects of Ivalon implantation upon the dog heart and the human heart, and references in the literature led us to believe that Ivalon was not injurious to human tissue The cases in which Ivalon was used were not selected prior to operation The judgment as to whether or not Ivalon would be implanted depended upon what transpired at the time of operation, *i e*, if large segments of the bony or cartilaginous septum had to be removed, or if tears in the mucous membrane occurred The ready availability, size and ease of handling Ivalon made it a superior implant to an isograft or any other foreign body substance with which we were acquainted

REPORT OF CASES

Case 1 R T a 53 year old white female was referred to us because of a deformed nose and difficult nasal breathing due to an injury sustained in an auto accident three years ago Examination revealed an external nasal deformity associated with a marked deflection of the nasal septum

Laboratory examination showed a white blood count of 6 700 hemoglobin 10 5 gms and hematocrit of 33 per cent Blood sugar was 109 mgm per cent and blood urea nitrogen 8 5 Urine was negative for albumin and sugar

A submucous resection combined with a rhinoplasty was done on

October 5, 1956 Most of the cartilaginous septum and a portion of the bony septum had to be removed An Ivalon implant was inserted to provide a support for the dorsum of the nose

She was given Penicillin 800,000 units daily for two days, then Terramycin 250 mgm three times a day for the following eight days The vaseline packing, which had been inserted into both sides of the nose was removed on the fifth postoperative day The cosmetic and functional results were good The Ivalon implant was apparently well tolerated, and when the patient was last seen in January of 1959, no change was noted in the nose

Case 2 A W, a 32 year old white male came to us with a complaint of nasal blockage associated with crusting and dryness of the nose Examination revealed a marked displacement of the nasal septum to the left with spur formation and obstruction of the nasal airway The patient showed clinical and laboratory evidence of nasal allergy

Laboratory studies showed a white blood count of 7,600, a hemaglobin of 15 5 gms, and a hematocrit of 50 per cent Urine was negative for albumin and sugar

A submucous resection of the nasal septum was done on August 28 1955 At operation the mucous membrane of both sides of the cartilaginous septum was very thin and atrophic, and a through and through tear occurred in spite of the meticulous technique An isogenous cartilage graft from the cartilage bank was inserted between the mucous membrane flaps in the area of the tears in order to provide a bed for the mucous membrane of both sides of the septum for the purpose of preventing a permanent perforation

No antibiotic was given postoperatively, and the vaseline packing which was inserted in both sides of the nose was removed the second postoperative day In spite of daily postoperative care, the isograft sloughed out completely on the tenth postoperative day and a perforation resulted Because of annoying bleeding and crusting, it was decided to attempt a closure of the perforation using an Ivalon implant

The operation was performed on September 15, 1956, one year and ten months after the first operation The perforation measured 2 cm in length and 1 cm in height The mucous membrane flaps were carefully separated, and an Ivalon implant measuring 3 cm by 2 cm was inserted and held in place with vaseline packing

Again, no antibiotics were given The packing was removed on the second postoperative day The mucous membrane edges would not heal and the Ivalon implant sloughed out on the fourteenth postoperative day A permanent perforation has resulted The tissue reaction to the Ivalon was moderate and was characterized by edema of a moderate degree and crusting

Case 3 E L a 57 year old white male was referred to us because of recurrent attacks of epitaxis and obstruction to breathing He had had cautery done to both sides of the septum elsewhere Examination revealed a marked deflection of the nasal septum to the left The bleeding point was difficult to localize because of the septal deformity A submucous resection of the septum was advised

Laboratory findings on admission showed a white blood count of 7,450 a hemoglobin of 15 gms, and a hematocrit of 49 per cent Urine was negative for sugar and albumin

The operation was performed on August 28 1956 During the course of the operation a through and through tear occurred in the mucous membrane at the site of the previously done cauterizations An Ivalon implant was inserted between the mucous membrane flaps to provide a bed upon which the edges of the torn membranes could heal

Penicillin in the amount of 400 000 units, twice daily was given for two days and the packing removed on the second postoperative day The mucous membrane completely bridged the perforation in the right side of the nose but did not heal over on the left side The Ivalon presented itself at the line of incision which had been made in the left vestibule and had to be removed finally through the unhealed line of incision ten weeks after the operation The implant was easily removed, indicating that there was little if any fixation due to ingrowth of adjacent living tissue The line of incision promptly healed and the septum was intact

Case 4 D B a 15 year old white female was referred to us because of an external nasal deformity and difficulty in breathing following an injury to her nose in childhood Examination revealed a deformed and depressed nasal bridge associated with a deflected septum which completely obstructed the airway on the left. A submucous resection was advised, to be followed two years later with a rhinoplasty

Laboratory findings on admission showed a white blood count of 7,800 a hemoglobin of 12 gms and a hematocrit of 37 per cent Urine was negative for albumin and sugar

The operation was performed on August 31 1956 The cartilaginous septum was so badly deformed and fragmented that most of it had to be removed An Ivalon implant was inserted between the mucous membrane flaps and held in place with 2 0 chromic catgut mattress sutures

Penicillin 400 000 units once daily was given for three days The vaseline packing was removed on the second postoperative day The Ivalon was apparently well tolerated and the single incision made in the left vestibule healed, however ten weeks after the operation the Ivalon implant presented itself through the old line of incision and had to be removed four months after implantation

The implant was readily removed, indicating little if any fixation by infiltration of living tissue The line of incision promptly healed

Case 5 A K a 49 year-old white male was referred to us because of a deformed nose and obstruction to breathing due to a recent fracture of the nose superimposed on an old healed fracture Examination revealed an external nasal deformity associated with an obstructing deviation of the septum to the right A submucous resection and rhinoplasty was advised

Laboratory findings on admission showed a white blood count of 8 100 a hemoglobin of 12 gms and a hematocrit of 38 per cent Urine was negative for sugar and albumin

The operation was performed on October 4 1957 The destruction and deformity of cartilage and bone of the septum made it necessary to insert an Ivalon implant to aid in stabilizing the nose The usual transfixion incision had been made The implant was fixed with 3 0 chromic catgut mattress sutures

No antibiotic was given The packing was removed on the fourth postoperative day The transfixion incision healed on the right side of the septum but persisted on the left An inflammatory reaction with a mucopurulent drainage, pain and edema set in and the Ivalon implant protruded through the incision one month after the operation The drainage persisted until the Ivalon was removed ten weeks later The implant was readily removed indicating little if any fixation by intil tration of living tissue. The inflammatory reaction quickly subsided and the line of incision healed.

Case 6. T. A., a 23 year old white male was referred to us because of difficulty in breathing through the nose, following a football injury in his high school days. Examination revealed a marked deflection of the nasal septum to the left with obstruction of the airway. A submucous resection of the septum was advised.

Laboratory findings on admission showed a white blood count of 9,600, a hemoglobin of 13 gms., and a hematocrit of 44 per cent.

The operation was performed on November 17, 1958. A transfixion was made. Since most of the cartilaginous septum had to be removed an Ivalon implant measuring 2 cm. by 5 cm. was inserted and anchored with 3-0 chromic catgut mattress sutures.

Penicillin, 600,000 units and Streptomycin 0.5 gms. was given daily for four days. The nasal packing was removed on the third postoperative day. The postoperative course was uneventful.

Two weeks following surgery, it was noted that the left nasal vestibule became occluded by marked hyperplasia of the soft tissue of the columella making it difficult for the patient to breathe. Since the swelling did not subside the patient was taken to surgery for a revision operation on January 3, 1959, two months after the initial surgery. It was decided to remove the Ivalon with a portion of the adjacent mucous membrane though it was apparently being well tolerated. This was done for the purpose of histologic study.

It was noted that the mucous membrane peeled off easily from the underlying Ivalon implant. In fact, a segment of mucous membrane had to be sutured to the underlying Ivalon before a representative specimen could be obtained. The histologic findings will be presented later. Recovery was uneventful.

Case 7. J. P., a 43 year old white male was referred to us because of nasal blockage. Examination revealed a deflection of the nasal septum blocking the right nasal airway. A submucous resection of the nasal septum was advised.

Laboratory findings on admission showed a white blood count of 6,100, a hemoglobin of 12.9 gms., and a hematocrit of 42 per cent. Urine was negative for albumin and sugar.

The operation was performed on December 29, 1958. Because of the amount of septal cartilage removed an Ivalon implant measuring 2.5 cm. by 5 cm. was inserted and sutured in place with 3-0 chromic catgut sutures.

Patient was placed on Aureomycin 250 mgm. every six hours and 600,000 units of Penicillin daily for three days. The packing was removed on the second postoperative day and the patient discharged. The following day he presented himself with nasal obstruction due to marked edema of the nasal mucous membrane of the septum. He showed no systemic evidence of infection and had no complaints other than the obstruction. Aspiration needling failed to yield pus or old blood. He was finally taken to surgery one week later and the Ivalon implant removed. Cultures taken from the bed where the implant laid showed few coliform bacilli and a few Staphylococcic aureus of the hemolytic type. The implant was removed with ease. The edema gradually subsided. Patch tests on the forearm made with fresh Ivalon and segments of the removed Ivalon specimen showed no skin reaction after 24 and 48 hours.

Two additional cases of through-and-through tears in the nasal mucous membrane occurring at the time of operation warrant inclusion in this series though Ivalon was not used In both instances isografts from our cartilage bank were implanted in the septum to provide a bed for the growth of the epithelial tissue One occurred in a young man of 17 and the other in a 47-year-old adult In the former patient the center of the graft necrosed and a small permanent perforation resulted In the latter patient the entire graft sloughed out, and a large perforation resulted In Case 2 of the Ivalon series an isogenous nasal cartilage graft used at the time of the original operation sloughed out making a total of three cases in which isografts failed to prevent the formation of perforations

In summary seven cases ranging from 17 to 57 years in age were presented The Ivalon implant has been retained in one case for over two years One implant which was apparently being tolerated well was removed for histologic study The implant was rejected by the host tissue in five cases Only in one case could true infection be demonstrated In five cases the Ivalon was implanted because of extensive removal of cartilage and bone from the septum In two cases it was implanted to prevent permanent perforations Antibiotics were not routinely used nor given in large doses as in heart surgery Five operations were submucous resections alone and two were rhinoplasties combined with submucous resection Three additional cases (including Case 2 in the original series of seven), in which isografts from a cartilage bank were used to prevent perforations were appended In all three cases the isografts were rejected totally or partially and permanent perforations resulted

DISCUSSION

At this point in the presentation the casual reader might hastily conclude that Ivalon is unsuitable as a nasal septal implant since in five and possibly six of seven cases the Ivalon was not retained to date (in Case 6 an apparently well tolerated Ivalon implant was deliberately removed for histologic study) There is a wise old saying to the effect that we learn from our failures, not our successes We had to ask ourselves the question why to date Ivalon was rejected in five (or possibly six) out of seven cases when implanted in the nose, yet was well tolerated, as far as could be determined in 35 cardiac implants in the human heart (Dr Kralik's series) We also had to ask ourselves the question why human nasal cartilage isografts utilized in three cases appended for comparative study were likewise rejected in whole (two cases) or in part (one case)

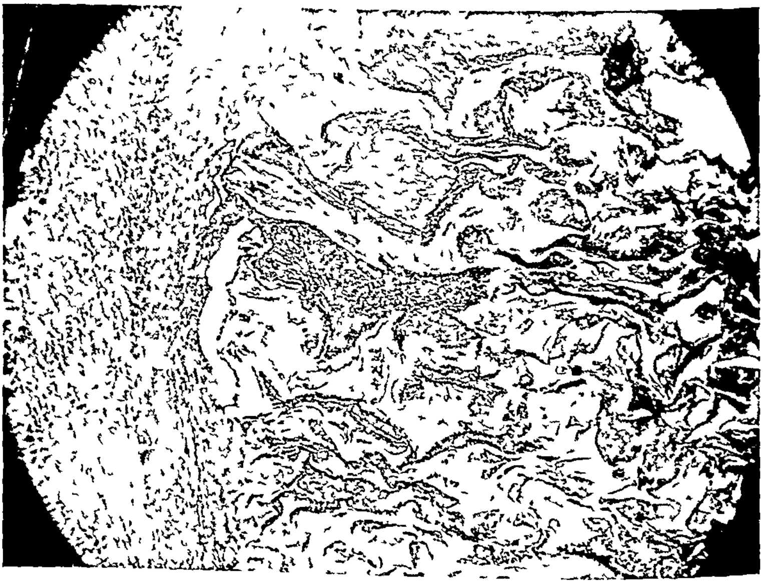

Fig 1 Microphotograph of a dog's heart removed ten days after Ivalon implantation

The apparent failures for the implant to be accepted cannot be attributed to faulty technique as we followed the usual procedures we did in routine submucous resections and rhinoplasties, nor upon infection, for in only one case was a mild infection demonstrated The answer as to why the Ivalon implant was accepted in the heart and not in the nose must be attributed to something in the inherent nature of the two respective tissues To study this problem further we enlisted the aid of Dr J Kralik, who furnished the heart specimens obtained from dogs which had been sacrificed at varying periods after Ivalon had been implanted in the animals He also made available to us a specimen of a human heart from a patient who died of congestive heart failure 30 days after Ivalon was implanted to cover an atrial septal defect Dr E Siegler, Director of Laboratories, very kindly consented to do the histologic studies

Figure 1 is a photomicrograph from a slide of the heart of a dog sacrificed ten days after Ivalon was implanted to close an artificially produced inter-atrial septal defect The endocardial surface is to the left One notes an exuberant, acute inflammatory reaction extending from the endocardial side into and between bundles of Ivalon This reaction under higher magnification consists of fibrin, red cells and polymorphonuclear leukocytes and edema fluid

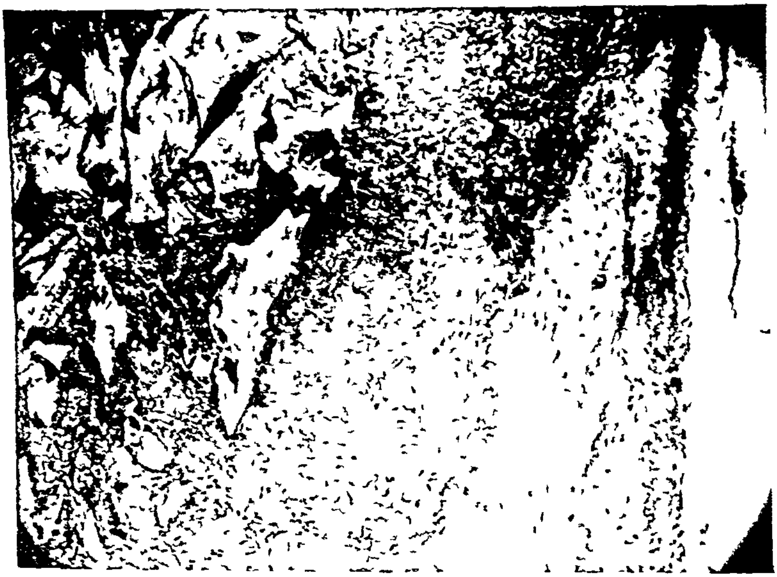

Fig 2 Microphotograph of a human heart removed at autopsy 30 days after Ivalon implantation

Figure 2 is a photomicrograph of a section from a human autopsy heart examined 30 days after Ivalon was implanted to close an atrial septal defect In the area photographed, which is at the junction of the Ivalon and the auricle, one notes the usual constituents of granulation tissue, namely, fibrin, proliferating fibroblasts, round cell infiltration and newly formed capillaries and veins At about the center of the photograph, the straight line relationship between the Ivalon on the left and the auricle on the right is no longer seen There is a foreign body type of giant cell reaction present immediately adjacent to some of the Ivalon fibers The most important finding demonstrated is the extensive infiltration of the granulation tissue into the interstices of the Ivalon In the central portions of the Ivalon only fibrin and inflammatory cells are seen Presumably the fibroblasts have not had time to move in

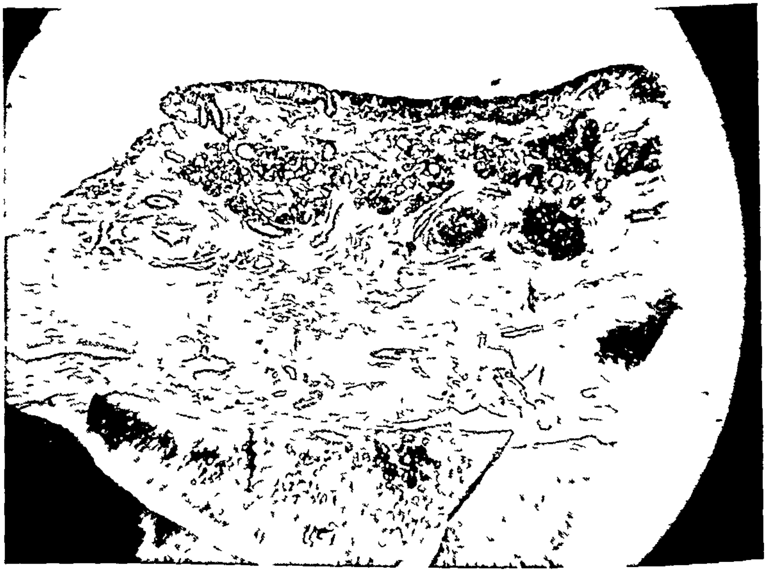

Fig 3 Microphotograph of a normal human septum taken under low magnification

Figure 3 is a low power view of a normal human nasal septum At the top of the photograph is non-keratinized squamous epithelium In the lamina propria one found the usual mucous and serous glands Arteries and veins are present in this layer as well as in the perichondrium layer A layer of cartilage is seen at the bottom of the photograph

Figure 4 is the most significant microphotograph in this series It shows a section of nasal septal mucous membrane adjacent to Ivalon implanted into a patient's nasal septum and removed 60 days following surgery The photo illustrates why the entire implant was removed with relative ease Unlike the hearts, the Ivalon to the left has not been infiltrated to any extent by granulation tissue In other words, the straight line relationship between the sponge and the nasal tissue has been retained almost completely An occasional foreign body giant cell is present at the junction of the lamina propria and Ivalon Only a small amount of granulation tissue is found in the interstices

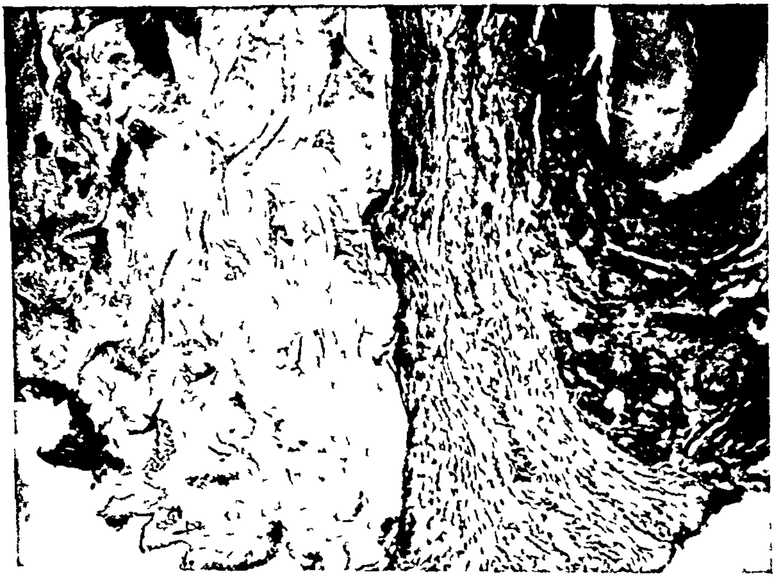

Fig 4 Microphotograph of a section of Ivalon covered by nasal mucous membrane Specimen removed 60 days after implantation of the Ivalon

Figure 5 shows one of the few large foci of granulation tissue invasion seen in the center of the Ivalon specimen

Figure 6 is a photomicrograph from a slide of the heart of

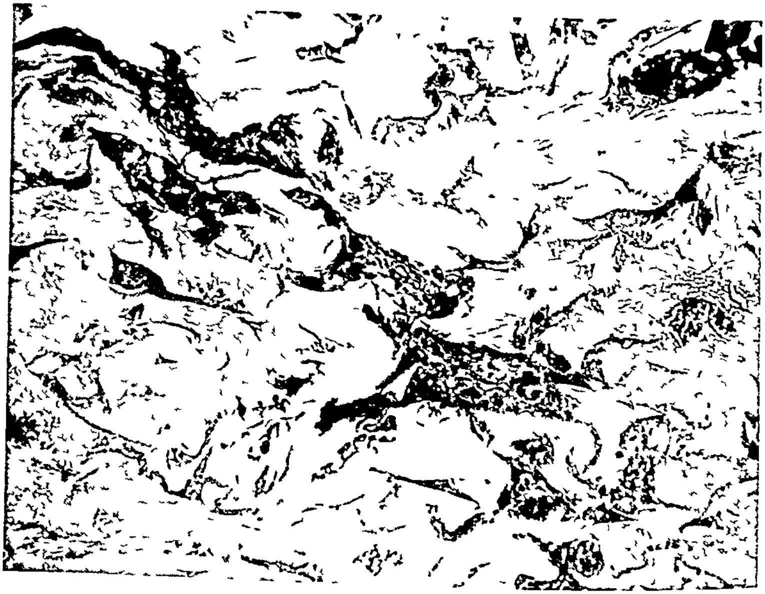

Fig 5 Microphotograph of a focus of granulation tissue in the center of the Ivalon specimen

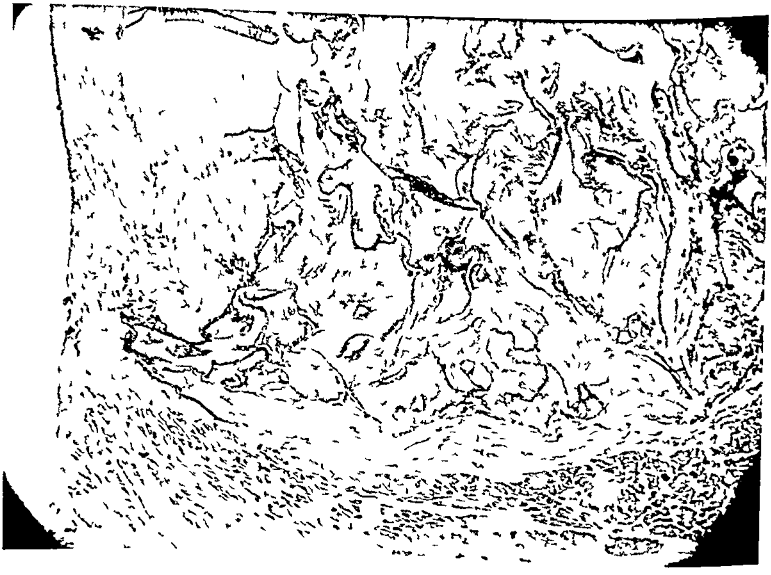

Fig 6 Microphotograph of a dog's heart removed 90 days after Ivalon implantation

a dog sacrificed 90 days after Ivalon was implanted to close an artificially produced inter-atrial septal defect The Ivalon sponge occupies the field at the top of the photograph and normal myocardial fibers are seen at the bottom of the picture Dense, hyalinized fibrous tissue has formed a complete capsule around the sponge and can be seen to have infiltrated the sponge to an extensive degree The vertical band to the left is one of the endocardial layers This is the type of end result one would like to see in all artificial implants

We do not feel that the differences in degree and type of reaction between what occurs in the human and dog heart as compared to what happens in the human nose, which were so graphically illustrated in the microphotographs, can be explained merely on the basis of variations in the blood supply, the presence of a barrier such as the perichondrium, or upon environmental factors such as drying currents of air We feel that another and perhaps more potent factor might be that of local tissue immunity, or, as we would prefer to express the term, local tissue resistance

Williams, in speaking of lethal granulomatous ulceration, stresses the marked localizing powers of skin and mucous membrane[11] The midline facial tissues may possess greater localizing powers than the tissues in other parts of the body, in this instance the heart Kahn, in discussing tissue immunity and its possible relationship to midline facial granulomatous ulceration makes the pertinent observation "Apparently the exposed tissues of the body carry a tremendous burden of defense Through evolutionary ages these tissues have had the task of warding off micro-organisms and preventing their entrance into the blood stream and into deeper tissues It is this great burden that these tissues carry that is unquestionably related to allergic disturbances Like over-vigilant guards, the surface cells begin to treat substances as though they were harmful micro-organisms and react with great intensity on slight provocation"[12] Wilson and Miles, in speaking of body defense mechanisms, conceive a type of immunity confined to one particular area of the body or to one particular kind of tissue[13] Conley in discussing the principle of cooling as applied to the composite graft in the nose attributed the gratifying results he attained by utilizing this method to diminution of the biological activity demands of the graft until normal physiological processes had attained the level of survival[11] In our opinion an equally valid explanation might be that the defense mechanism of the recipient site may have been depressed by the cooling to such a degree that the graft had an opportunity to "take"

SUMMARY

A report was submitted on the fate of Ivalon which was implanted into the nasal septum of seven individuals. Three additional cases in which human cartilage isografts were utilized for the same purpose were appended In five and possibly six of the cases in which Ivalon was used, the implant was rejected by the nose The implants were rejected in whole or part in all three cases in which isografts were inserted

Histologic studies of tissue reaction to Ivalon in the human and dog hearts were made and compared to the reaction to Ivalon in the human nose A marked difference was noted in the degree and type of reaction The hypothesis was made that this difference was due in part to the high degree of tissue immunity (or resistance) to Ivalon inherent in nasal tissue as contrasted to that present in heart tissue

ACKNOWLEDGMENTS

I take this opportunity to acknowledge my indebtedness and to express my gratitude to Dr Edward E Siegler, Director of Laboratories and to Dr John J Kralik, Head of the Department of Cardiovascular Surgery, both of Marymount Hospital, Garfield Heights, Ohio, for the splendid cooperation that they gave me in the preparation of this paper

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AMERICAN HEARING SOCIETY MOVES

National headquarters of the American Hearing Society were moved to 919 18th St, N W, Washington 6, D C, during the Christmas holidays The agency occupies first floor space in an eight-story building which is being remodeled and converted from apartments to offices

LOW GRADE CANCER OF THE ETHMOID SINUS*

DELMAR F. WEAVER, M D ,

Detroit, Mich

Cancer that involves the paranasal sinuses is one of the most tragic diseases that we, as otolaryngologists, encounter At least 60 per cent of the patients that have this condition do not survive five years, in spite of the best available treatment Those who do survive usually have significant deformities and annoyances

Resection of the upper jaw for this condition has been carried out for more than 125 years When Blandin[1] reported his case in 1834, he stated that several other authentic cases of removal of the superior maxilla had been recorded

At the beginning of this Century interest developed in the destruction of these tumors with the actual cautery Success with this method led to the use of electrocoagulation with one of the machines that destroys tissue by extreme dehydration The results reported following the use of this method by such men as New,[2] Ohngren,[3] Schall[4] and others led to considerable optimism in dealing with this problem, since up to 40 per cent of the patients treated in this manner survived five years

Several of these reports were based on quite a large number of patients

In more recent years enthusiasm for a return to conventional cold instrument surgery in resection of these tumors has developed in some quarters This seems to have followed the advances that have been made in the handling of surgical problems in general, such as in anesthesia, blood replacement, antibiotics, skin grafting and teamwork

Cold instrument resection of the upper jaw can now be

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*Read at the meeting of the Middle Section of the American Laryngological Rhinological and Otological Society St Louis Mo Jan 13 1959

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carried out with a low degree of postoperative mortality It is an excellent operation for the teaching of surgical technique, since it follows certain known anatomical routes and can be described, demonstrated and illustrated, however, available statistics show the best results are obtained in those cases which have been treated by a plan which includes electrocoagulation and, in certain cases, irradiation

In the past 15 years approval of the use of electrocoagulation has been expressed by Cranmer,[5] Poulsen,[6] Larsson and Martensson,[7] Hara,[8] Erich[9] and others Hara[8] records the fact that in one hospital where 30 cases of cancer of the sinuses had been treated, the only two that survived five years had been treated by electrocoagulation

Time does not permit an adequate discussion of this phase of the subject In 1952 the speaker reviewed the literature thoroughly, and reported to this Society the relative results following the various methods and combinations of methods of treatment of cancer of the sinuses[10] A review of the recent literature confirms the impression that there is a distinct advantage in the use of electrocoagulation in experienced hands

About 80 per cent of cancers which involve the paranasal sinuses originate in the maxillary sinus It is likely that some of those that originate in the ethmoid sinus spread to the maxillary so soon that the exact point of origin cannot be determined The treatment of cancer of the ethmoid sinus in a large per cent of such cases is simply an extension of the treatment that is carried out for that of the maxillary, however, in some cases the tumor has originated in the ethmoid sinuses with little question, although extension into the other sinuses may have taken place to a certain degree Larssen and Martensson[7] found 19, or 5 6 per cent of 334 cases arising from the ethmoid Hara[8] found that in 5 or 5 5 per cent of 92 cases the ethmoid air caps alone were involved Havens and Thornell[11] reported four cases of cancer originating in the ethmoid sinus Harrison[12] reported two cases of lymphosarcoma of the ethmoid We have treated two cases of relatively high grade cancer originating in the ethmoid sinus The eye was sacrificed in both cases and electrocoagulation carried out through the fronto-ethmoid incision[10] Radium element was placed in the cavity immediately Supplemental Roentgen therapy was given both cases at the suggestion of the Roentgenologist These patients are without local recurrence nine and twelve years respectively One patient developed cervical metastasis in the opposite side and three months later on the side of the sinus tumor Radical neck dissection was carried out on each side at separate times and he is without recurrence six years since the last operation

Single cases of cancer of the ethmoid have been reported by Munson and Munson,[13] Harrison,[12] Schall,[14] Hibbs and Telch,[15] Tolczynsky,[16] Harper[17] and High[18]

The type of cancer involving the sinuses is squamous cell carcinoma (epidermoid) in a high per cent of cases Sarcoma is much less common and adenocarcinoma relatively rare Further pathological classification may be confusing, due to a certain variation in terminology and is consequently beyond the realm of this paper, however, since adenocarcinoma of the cylindroma type was present in one of the case reports to follow, something of its characteristics and its relative frequency of occurrence is thought to be of interest

This tumor may be called adenocarcinoma, adeno-cystic carcinoma, adenoid cystic carcinoma, adenoid cystic basal cell carcinoma, adenoid cystic epithelioma, basal cell carcinoma with hyaline stroma, adenomyoepithelioma, adenocarcinoma of cylindroma type, cellular mixed tumor, basaloma and cylindroma

In 1859 Billroth[19] described a cylindroma of the parotid gland and referred to an earlier case of cylindroma of the orbit He is generally given credit for the first description of the tumor

Histologically the cylindroma is characterized by the arrangement of small darkly staining cells with relatively little cytoplasm, closely contiguous in anastomosing cords between which are rounded cellular areas which may contain mucus, hyaline or muco-hyaline material

Beck and Guttman[20] used the term basaloma for this tumor and found but 37 cases involving the respiratory passages and their adnexa in the literature and added three cases of their own Although the maxillary antrum was involved in over half of them there was no case in which the ethmoid alone was involved

One of the most important characteristics of the cylindroma from a practical standpoint is the lack of correlation between the histopathology and clinical behavior While the microscopic picture is one of a very low grade of malignancy, the tendency to local recurrence and metastasis is often marked Attention has been brought to this fact by Pollock[21]

Frequency of Occurrence of Adenocarcinoma and Cylindroma in Cancer of the Paranasal Sinuses

Author	Cancer Cases	Adeno-Carcinoma	Per cent	Cylindroma	Per cent
Larsson and Martensson	334	11	3 3	34	10 2
Schall	219	22	10	1	4
Geschickter	139	15	10 8	15—Cystic Basal Cell Ca	10 8
Watson	121	11	9	0	0
Hara	92	10	10 8	0	0
Cranmer	91	5	5 5	2	2 2
New	91	6	6 6	0	0
Beatty	37	3	8	0	0
Poulsen	19	2	10 5	0	0
Haas	23	0	0	1	4 3
McKenzie	10	0	0	1	10
Totals	1176	85 (7 2%)		54 (4 6%	

Fig 1

A combined total of 1176 cases of cancer of the sinuses reported in eleven articles included 85 which were classified as adenocarcinoma, an incidence of 7 2 per cent In addition there were 54 cases classified as cylindroma, an incidence of 4 6 per cent This group included 15 cases called cystic basal cell carcinoma rather than cylindroma (see Fig 1)

While the occurrence of cases classified as adenocarcinoma was rather consistent in the various reports, that of cylindroma was not Five authors reported no cylindroma while two reported an incidence of over 10 per cent This may be largely due to the variation in terminology

Schall[22] feels that the surgical approach to tumors of the sinuses should depend on the point of maximum involvement He states that if exophthalmos exists and if it is questionable whether the orbit has been involved, the ideal approach is through the orbit by an exenteration of the orbital contents

In 1944 Havens and Thornell[11] thoroughly reviewed the literature dealing with the development and technique of the fronto-ethmoid incision and reported its use on eight cases of carcinoma of the nasal cavity and paranasal sinuses

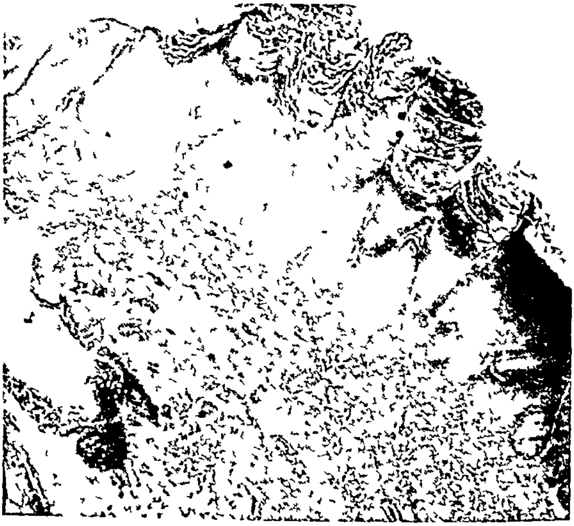

Fig 2a Squamous Pappilloma ×21

As a rule the degree of malignancy of cancer of the sinuses requires the most active and extensive treatment that one feels is consistent with safety There are times, however, when the tumor is thought to be of sufficiently low grade to justify some conservatism in its treatment This fact, combined with the unusual occurrence and characteristics of the following two cases, is the reason for reporting them

Case 1—A white man, 35 years of age, was seen by a well qualified Detroit otolaryngologist in 1939 He complained of inability to breathe through the left side of his nose and intermittent attacks of pain over the left frontal and maxillary sinus region There was history of having had bilateral iridectomies for glaucoma in 1932 There was no useful vision in the right eye A left Caldwell Luc operation was performed and multiple polyps removed from the left nasal cavity A partial removal of the left middle turbinate was done also

A well qualified Detroit pathologist made the following report Squamous and columnar epithelium surmounting a loose areolar connective tissue A few lymphocytes are infiltrating the stroma Other sections are covered by stratified columnar epithelium The stroma is edematous and myxomatous and infiltrated by lymphocytes

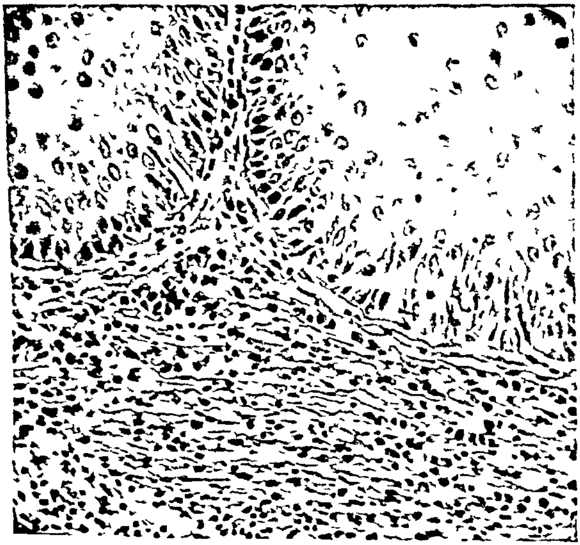

Fig 2b Squamous Papilloma X185

Diagnosis Infected nasal polyps

Polyps were removed again in 1942 1944 and 1945

The pathological report in 1945 was Chronically infected nasal polyps with excessive hyperplastic surface epithelium A foot note stated "It is my opinion this polyp would become squamous cell carcinoma if allowed to develop further It is on the border of malignancy at this time"

In 1946, one year later microscopic examination of removed tissue was reported in much the same way

At this time the patient was referred to an excellent out of state medical center where the chief pathologist and chief otolaryngologist and an associate agreed that the tumor in the ethmoid region would probably remain benign and more radical surgery was considered optional It was recommended that he be seen every six months for several years This was done

I saw him first on February 19, 1950, at which time there was a polyp 6 cm in diameter in the left middle meatus He returned to the out of state medical center, where a submucous resection was carried out with removal of polyps from the left ethmoid region A left nasoantral window was made also This was presumably an enlargement of the original antrum window put in at the time of the Caldwell Luc

I removed tissue from the ethmoid region in May, June and July of 1950

In 1952 I removed more tumor and sent him to the out of state medical

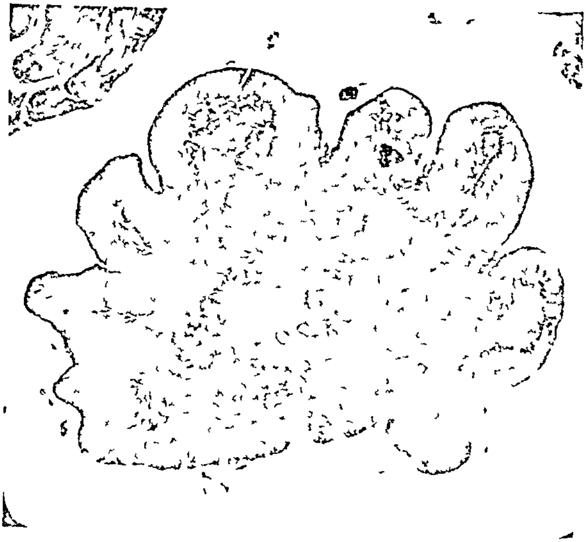

Fig 3a Squamous Cell Carcinoma X21

center for re evaluation After examining the recently removed tissue it was decided that the tumor was still benign and surgery optional

I removed more of the tissue in 1952 and again in 1953, at which time the Detroit pathologist made essentially the same report as he had previously Squamous epithelial and adenomatous polyps of nose Squamous type tend to recur and sometimes become malignant (see Figs 2a and 2b)

Nine months later I removed further tissue and the diagnosis by a local pathologist was squamous cell carcinoma A slide was sent to the out of state medical center where the diagnosis of carcinoma was confirmed, and it was termed pseudo papillary squamous cell epithelioma It was considered not infiltrative and not remarkably high grade There were other areas which showed benign papillomatous structure (see Figs 3a and 3b)

Roentgenograms at this time showed cloudiness of the left ethmoid sinus with involvement of the left frontal and maxillary (see Fig 4)

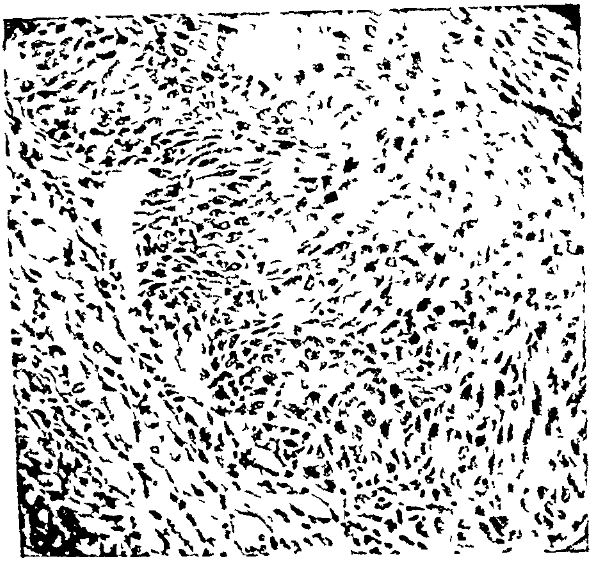

Fig 3b Squamous Cell Carcinoma X185

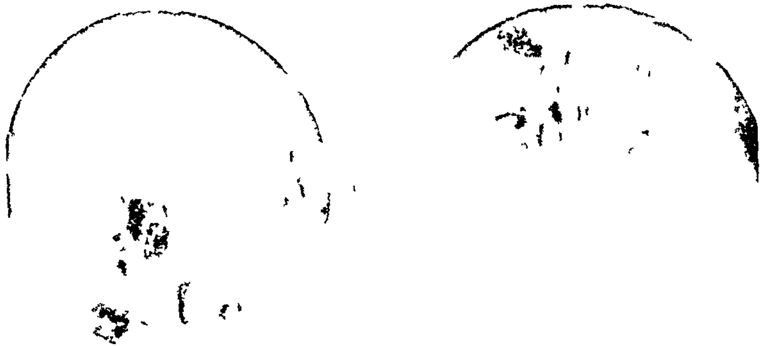

Fig 4 Roentgenograms of Sinuses showing cloudiness of left ethmoid frontal and maxillary sinuses

There seems little question that the transformation of nasal polyps to carcinoma occurred in this case Tolczynsky[16] states that such an occurrence is extremely rare, and this fact is no doubt responsible for the long delay in carrying out more radical surgery

Schall[14] reported the case history of a woman who had had polyps removed every year for about 10 years with no microscopic examination When this was done it revealed epidermoid carcinoma of the ethmoid labyrinth

On September 14, 1958, the following operation was carried out by the author Under Pentothal Sodium anesthesia an incision was made extending along the left side of the nose upward medial to the inner canthus and along the lower border of the inner third of the eyebrow The skin and periosteum was elevated anteriorly and then posteriorly as far as the anterior ethmoid artery, which was ligated and then cut on the nasal side

The anterior ethmoid cells were entered through the lacrimal fossa These cells contained cancer A complete ethmoidectomy was carried out The floor of the frontal sinus was then removed as was the anterior wall of the sphenoid sinus The edematous and swollen mucous membrane was removed completely and thoroughly from these sinuses The left maxillary antrum was entered from the ethmoid region and the mucous membrane removed from it Thorough electrocoagulation of the soft tissue surrounding the operative field was carried out but it was felt unneccessary to electrocoagulate the remaining bone

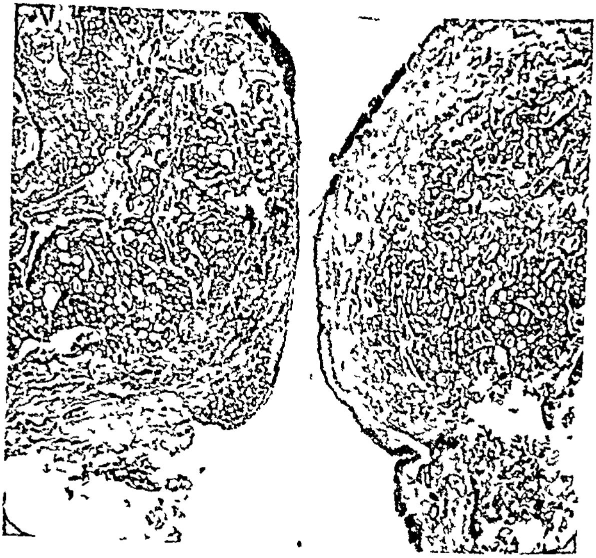

Fig 5a Cylindroma X21

The wound was closed with heavy Dermalon retention sutures and fine silk skin sutures

A 26 F rubber tube was passed into the frontal sinus through the nose and left in place for ten days

Microscopic examination of all the tissue removed at operation indicated that the tumor extended into the maxillary and sphenoid sinus to a limited degree

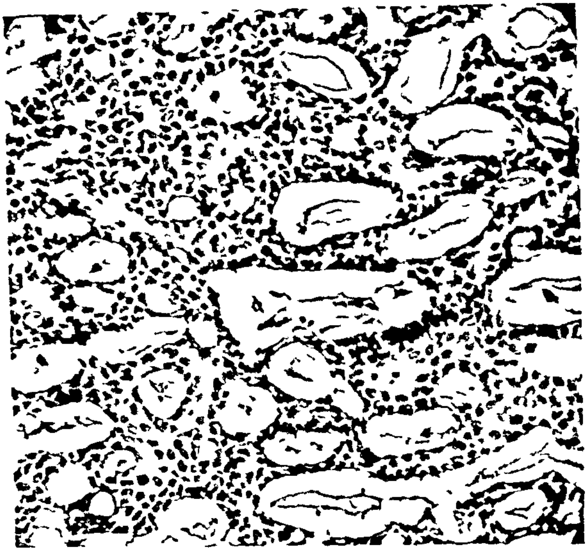

Fig 5b Cylindroma X185

Fig 6 Normal Roentgenograms of the Sinuses

The patient has been symptom free for four and one third years Biopsies of small tags removed from the ethmoid region on several occasions have been reported squamous papilloma but there has been no significant recurrence of the tumor He is followed closely, however and the possibility of having to reoperate upon him in the future is recognized

Case 2 A white woman, age 55, was first seen on May 26 1958 She stated that a year previously she had noticed a swelling developing between the bridge of the nose and the inner canthus of the right eye This had grown gradually For a year she had had pain in and around the right eye radiating to the right half of her head and down to her neck There had been recent recurrent bleeding from the right side of the nose

On examination there was a firm subcutaneous tumor about 1 cm in diameter just medial to the inner canthus of the right eye and extending up to the region of the floor of the frontal sinus It was not movable and not attached to the skin

On examination of the right nasal cavity there was found a polypoid tumor 3 to 4 cm long and apparently arising in the ethmoid region Biopsy of this was reported adenoid cystic carcinoma (cylindroma) (see Figs 5a and 5b)

It was considered a low grade of malignancy and of slow growth but prone to local recurrence and distant metastasis, particularly to cervical lymph nodes

Roentgenograms of the paranasal sinuses were entirely normal (see Fig 6)

General physical examination and laboratory studies including an electrocardiogram revealed no significant abnormalities

Roentgenograms of the chest showed pulmonary emphysema and fibrosis Gall bladder studies were normal

On June 5, 1958, through a fronto ethmoid approach the tumor, 1½ to 2 cm in diameter was encountered just under the skin and subcutaneous tissue having eroded through the bone It extended through the ethmoid sinus region and into the nasal cavity, being 4 to 5 cm long and free of attachment except in the ethmoid region After removal of the tumor the surrounding area was electrocoagulated thoroughly This included the right side of the nasal septum and destroyed most of the right nasal bone and the nasal process of the superior maxilla on the right side Since the frontal duct was involved, the floor of the frontal sinus was removed entirely so that the orbital contents could obliterate it as completely as possible The partition between the frontal sinuses was removed so that drainage could pass to the left side if necessary

A number 26 F rubber catheter was passed into the frontal sinus through the nose and the wound was closed with Dermalon and fine silk sutures The patient was dismissed from the hospital on the seventh postoperative day, and the rubber drainage tube removed at that time

Five months later there is no evidence of recurrence

CONCLUSION

Two cases of primary cancer of the ethmoid sinus of relatively low grade have been reported in some detail The first case is most unusual, because there appears little doubt that squamous cell carcinoma developed in benign polypoid tumors that had repeatedly recurred over a period of 15 years The rarity of this occurrence is no doubt responsible for the long period of time before more radical surgery was carried out Extensive electrocoagulation and heavy irradiation was thought unnecessary because of the low degree of malignancy of the tumor and unwise because of blindness in the opposite eye

The second case is interesting chiefly from the standpoint of the relatively rare cylindroma originating in an ethmoid sinus

Advantage has been taken of the opportunity to discuss briefly cancer of the paranasal sinuses in general

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ESOPHAGOGASTRIC SPHINCTER INCOMPETENCY

F JOHNSON PUTNEY, M D ,

Philadelphia, Pa

The clinical problems of benign lesions of the lower end of the esophagus are basically anatomic problems, and the controversy started in 1719 by Helvetius'[10] description of a morphologic sphincter at the cardioesophageal junction still exists Mosher[11,12] at one time asserted that the cardiac sphincter was definite and at a later date stated that it did not exist

A great deal of information on gastroesophageal regurgitation and hiatal hernia has accumulated in the literature in recent years and pressure readings at the lower end of the esophagus, as performed by Olsen[1] and others[2-7] have helped to determine the part played in gastroesophageal regurgitation by both intrinsic and extrinsic factors, causing elevation of intragastric pressures Even though these manometric pressure studies have increased our knowledge, the exact mechanism of gastroesophageal sphincter function remains in dispute The prevailing opinion today is that a physiologic sphincter is present at the esophagogastric junction, and while it does not have the anatomic features of a true muscular sphincter it acts in such a way as to prevent reflux regurgitation of material from the stomach into the esophagus unaided by any pinch-cock action

Lendrum[8] demonstrated that the distal esophageal epithelium terminates not in a straight line but in a jagged, irregular and angulated line The constriction at the esophagogastric junction is formed by a thickening of the circular muscular fibers There is no evidence to support the theory that the hiatus acts as a pinch-cock to close the cardiac end of the esophagus, for its grip on the esophagus is insufficient to prevent the normal sliding movement which occurs during respiration Davis[9] demonstrated that the level of the esopha-

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*Read at the meeting of the Eastern Section of the American Laryngological Rhinological and Otological Society New York N Y Jan 8 1959

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gogastric constrictor in relation to the diaphragm was not fixed, and was within or above the hiatus during descent of the diaphragm in inspiration and fell below the hiatal level during expiration as the diaphragm rose The esophagogastric junction is located immediately below the inferior esophageal sphincter and is continuous with the cardiac constrictor, which is formed by a continuation of the circular muscle fibers of the esophagus reinforced by eliptical muscle fibers and covered by thick mucosa When viewed esophagoscopically the esophagogastric junction appears as a stellate or puckered orifice with a horizontal opening which remains closed except during the act of swallowing This sphincter-like area has been found histologically to consist of a fold of mucosa with deep thickened muscular fibers which act similar to valves The flap valve of mucosa at the exact point of junction of the esophagus and stomach offers no obstruction to the downward flow of material but is resistant to reflux, and pressure studies by Barrett[3] indicated that it operated over not more than a 5 mm area The efficiency of this mechanism is borne out clinically by the difficulty encountered in finding the cardiac opening into the esophagus when retrograde esophagoscopy is performed through a gastrostomy opening, and at times considerable pressure has to be exerted upon the mucosa at the esophagogastric junction in order to enter the esophagus from below Allison[1] noted also that when the esophagus and stomach were removed from the body greater pressure was needed to drive fluid from the stomach into the esophagus than in the opposite direction Even though no actual internal sphincter can be demonstrated there is an intrinsic mechanism contributing to continence at this level, and recent experimental work by Meiss and his associates[10] indicate that it lies within the esophagogastric junction

The maintenance of a competent esophagogastric sphincter mechanism seems to be dependent upon *1* an intrinsic morphologic sphincteric factor as yet ill defined, *2* the contraction of the circular muscle fibers of the esophagus and the oblique fibers of the stomach as they come together at an angle, *3* the valve-like flap of mucous membrane in this area, and *4* the diaphragmatic crus The latter alone cannot insure continence, and the size of the opening in the right crus of the diaphragm is so variable that an opening which is larger than normal does not always indicate a hiatal hernia. Normally the mucosa of the esophagus is protected from the acid gastric juice by the secretion of mucus and saliva and by its squamous epithelial lining. Regurgitation of gastric secretion into the lower esophagus is present in some cases and can be produced by increased intragastric pressure and distention without an actual hiatal hernia being present. In 1926 Robins and Jankelson[14] observed, in 103 cases studied roentgenologically, that 4.6 per cent had cardioesophageal relaxation in a variety of clinical lesions without any demonstrable esophageal disease.

TABLE I

Diagnosis in 184 Patients with Symptoms of Dysphagia and Pain from Lower Esophageal Disease

	Hiatal Hernia	Esophagogastric Incompetency
Roentgenography	142 \	2 \
	161	23
Esophagoscopy	19 /	21 /
Esophagitis	39	3

Gastroesophageal reflux with its resulting esophagitis is the cause of the most disabling symptoms of hiatal hernia, and the size of the hernia is no indication of the nature of the reflux or the amount of ulceration present. The severity of the symptoms does not always agree with the extent of the esophagitis, and the pain at times is not proportionate to the visible inflammation.

In a group of 184 patients (see Table I) seen during the past five years with symptoms of esophagitis, a definite hiatal hernia was demonstrated on roentgenographic study in 142 cases. In the remaining 42 cases with a normal esophagogram a hiatal hernia was found on esophagoscopy in 19 cases, and an incompetent sphincter without hiatal hernia was present in the other 23 cases. In approximately one-fourth of the 161 cases with hiatal hernia esophagitis, with or without ulceration, was observed esophagoscopically, but only three of the 23 cases of esophagogastric sphincter incompetency exhibited actual ulceration

In all of the cases observed the symptoms were those of esophagitis Dysphagia of some degree usually occurred on eating solid foods, and lodgment of food not infrequently resulted so that the patients found it necessary to take large quantities of fluids with meals Regurgitation was prone to occur after food intake and often interrupted the course of a meal Bending forward after eating produced regurgitation into the mouth, and the material or sour fluid regurgitated had to be swallowed again This usually left the throat feeling dry or burny Sometimes patients noticed lodgment of food at the lower end of the sternum, accompanied by pressure sensations that were relieved as the bolus passed into the stomach

The most severe symptom was that of pain either precordial, epigastric, in the back, or radiating upward into the shoulder, or downward into the abdomen The distress varied from a few minutes to hours with a corresponding inconstancy in the time interval, but as the esophagitis became more marked the pain became more constant and severe and increased on stooping or bending It commonly awakened patients at night, especially if they were sleeping on their backs, and relief was obtained by sitting upright or taking water, milk or alkalies The presence of gas and marked belching was also observed These symptoms are also similar to those of peptic ulcer, a condition from which esophagitis must be distinguished

The diagnosis of hiatal hernia can be made both roentgenologically and esophagoscopically, and it is now generally agreed that patients with symptoms of esophagitis should have an esophagoscopic examination, even though the Roentgen findings are negative With a positive Roentgen finding of hiatal hernia esophagoscopy establishes the presence and extent of the esophagitis as well as confirms the diagnosis

In the 23 cases of esophagogastric sphincter incompetency the symptoms were explained by the finding on esophago-

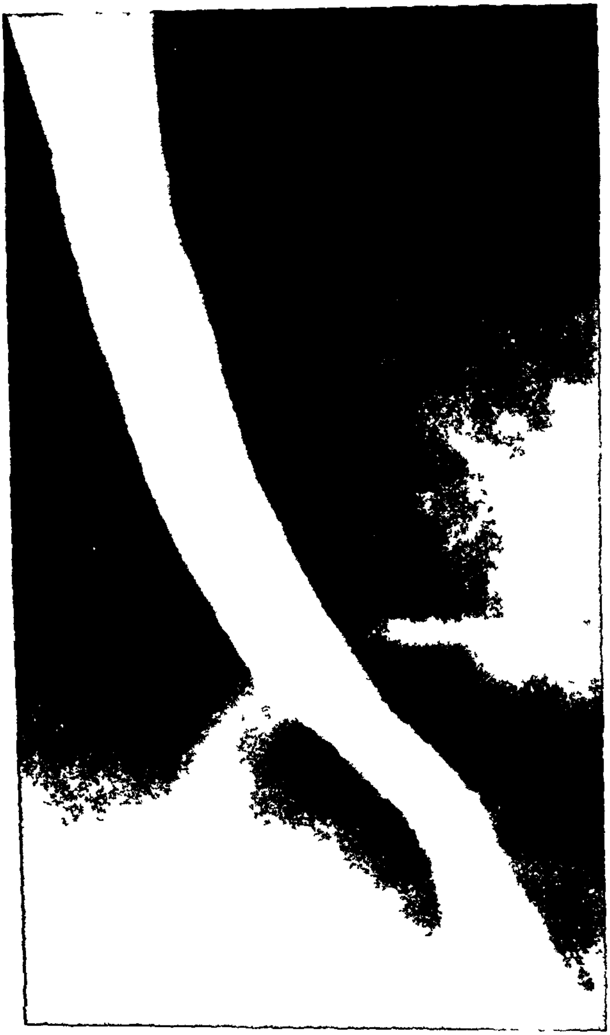

Fig 1 Roentgenogram of a patient with sphincter incompetency without hiatal hernia Esophagoscopy revealed a relaxed and incompetent esophagogastric junction in its normal location absence of the normal angle of entry of the esophagus into the stomach and extensive ulcerative esophagitis

scopic examination of an incompetent esophagogastric junction with loss of the normal angle of entry of the esophagus into the stomach (see Fig 1). In these cases no actual herniation was observed, yet the symptoms were due to the incompetent hiatal constriction Additional esophageal find-

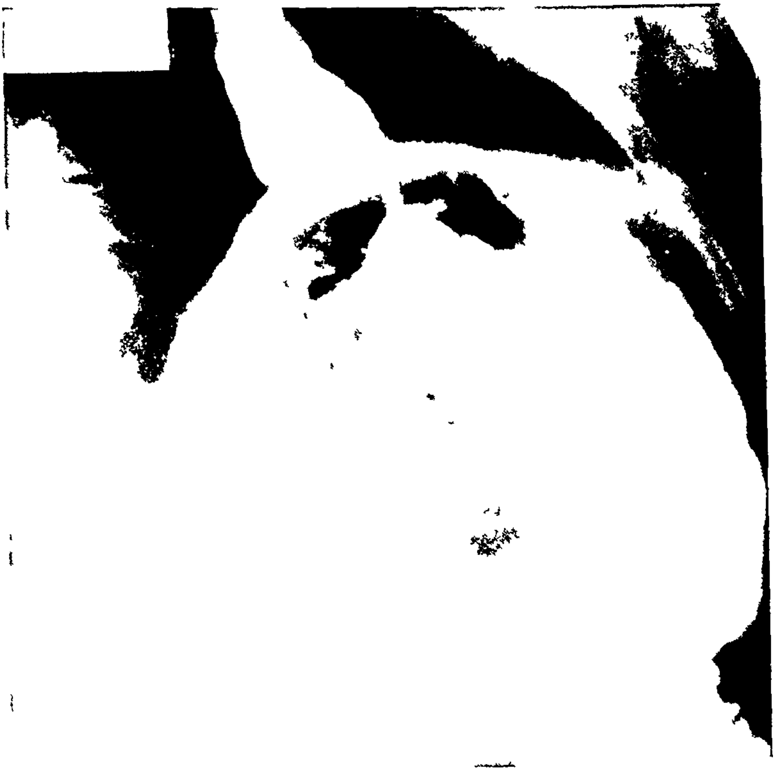

Fig 2 Postoperative roentgenogram of a patient after hiatal hernia repair in whom the esophagus was too short to allow displacement and establishment of an angle at the esophagogastric junction Even though the stomach remained below the diaphragm the persistence of the direct entry of the esophagus into the stomach permitted incompetency and esophagitis

ings were thickening of the mucous membrane with some redness and redundancy of the folds at the hiatal level The mucosa often bled easily, and occasionally small ulcerations were present Between the ulcerations which, varied from red to yellow, the mucous membrane was thickened and swollen Granulation tissue when present was usually flat and did not project into the lumen The esophagus was found to enter the stomach directly in a straight line rather than at an angle to the left and superiorly as is normally observed In one case extensive ulceration existed, which subsequently healed with narrowing and stenosis consisting of a funnel-like constriction, but no visible scarring similar to that seen in acquired strictures developed. In another case operated upon for repair of a hiatal hernia, the esophagus was too short to allow mobilization and establishment of an angle at the cardioesophageal junction, and although the stomach was placed below the diaphragm, incompetency persisted because of the vertical entry of the esophagus into the stomach (see Fig. 2). While the use of inflation in the lower esophageal segment is useful in visualizing a hiatal hernia with marked redundancy of the mucosal folds, ballooning of the hiatal area with air was rarely needed to demonstrate esophagogastric incompetency.

It has been my feeling that relaxation and incompetency is the first step in the development of a hiatal hernia, and these cases eventually progress to actual hernia formation. Since relief has thus far been obtained in this series by medical treatment, there has been no indication for further esophagoscopic examination. On the other hand, esophagogastric sphincter incompetency may simply be a manifestation of a reducible hiatal hernia and the incompetency results from the hernia. This latter hypothesis was not confirmed in the one case in which surgical exploration was performed, for no hernia could be demonstrated at operation. Wyllie and Field[16] reported six infants, age 1 month to 18 months, with intermittent esophageal regurgitation and hematemesis in which esophagoscopy revealed absence of the constriction at the esophagogastric junction, and incompetency of the sphincter but no actual herniation. In another case these identical findings were present in an infant who developed a definite hiatal hernia four weeks later as demonstrated esophagoscopically.

In recent years sporadic cases of esophagogastric sphincter incompetency have been treated surgically with reported relief of symptoms. Lortat-Jacob[9] sewed the greater curvature of the stomach to the lower esophagus, and Stensrud[15] performed a similar operation for incompetent cardia by suturing the fundus of the stomach to the left dome of the diaphragm.

Uncertainty remains as to the permanent results of medical treatment, but all of the patients in this group with esophagogastric incompetency improved under medical management Further study is needed to determine the subsequent development of a hiatal hernia Proper diet with thorough mastication of food afforded the most relief and bland low residue diets were used Aggravation of symptoms usually followed a heavy or large meal, and avoidance of large quantities of food and swallowing small amounts at a time were helpful Liquids taken during the course of a meal aided in washing down the food, particularly if there was a tendency for lodgment at the esophagogastric junction Any constriction or increased intra-abdominal pressure produced an increase in the symptoms and intensified them Reclining after eating was detrimental, and relief was obtained if the patient sat upright Sleeping in a semi-recumbent position was practiced routinely, and alleviated much of the night pain Careful attention to the diet usually sufficed so that medication was rarely indicated, but if so, alkalies and aluminum compounds were employed

SUMMARY

A mechanism exists at the esophagogastric junction, although its true nature has not been accurately established, which acts as a morphologic sphincter and prevents retrograde flow of gastric secretion When incompetency of the sphincteric action develops symptoms indistinguishable from those of esophagitis occur

In a series of 184 cases with esophagoscopically demonstrable esophagogastric sphincter incompetency, the cause was due to hiatal hernia in 87 5 per cent, and associated esophagitis was present in one-fourth In the remaining 12 5 per cent, incompetency of the esophagogastric sphincteric mechanism was the only finding, yet esophagitis was observed esophagoscopically in only three patients Medical treatment in the latter group has produced relief of symptoms

Esophagogastric sphincter incompetency is the initial step in the development of hiatal hernia in some cases, but further observation is necessary to prove this relationship in other cases

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USE OF ACRYLIC MATERIALS IN LARYNGOLOGY*†

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The problem of chronic stenosis of the larynx and upper trachea is a familiar one to laryngologists Although there has been a lessened incidence of the post-diphtheritic type and that due to faulty (high) tracheostomy, with subsequent perichondritis of the cricoid, this has been partially balanced by an apparent increase in the number of cases of traumatic origin Among the less important causes are acute non specific infections, tuberculosis, syphilis, cicatricial narrowing following operations on the larynx, and perichondritis following irradiation or intubation of the stomach ("feeding-tube stenosis")

The important and well-known items in pathogenesis are annular fibrosis and overgrowth of cartilage, the usual sequelae of perichondritis, and in some cases loss of support due to necrosis of cartilage An added factor, important in children and emphasized many years ago by Jackson, is failure of normal growth of the portion of the airway which is not functioning

Simple direct laryngoscopic dilatation has been used with success in many cases, particularly in childhood, where the stenosis is not of marked degree and where the tracheostomy has been performed at the proper level For some time, however, it has been recognized that more rapid progress can be made by the use of indwelling apparatus in increasing sizes Plastic procedures, with or without skin graft, have been used in instances of excessive overgrowth of fibrous tissue or cartilage, as well as in cases where support is deficient because of loss of cartilage In nearly all cases of marked

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stenosis, however, the use of indwelling molds will constitute an essential part of the treatment

In the past, molds of several types have been used Examples of these are the hard-rubber O'Dwyer tube, rubber core-molds of shape similar to the O'Dwyer tube and sections of ordinary urethral catheter, the latter having the advantage of being easily adapted to the individual case The rounded end rubber dilator of Jackson has been useful in the treatment of stenosis of the upper trachea

The most troublesome problem in the use of indwelling rubber apparatus has been the degree of inflammatory reaction induced Despite frequent changing, persistent mucosal ulceration with granulation tissue formation is frequent, and even reactivation of perichondritis may be observed Ideally, the material used for core-molding should be free of irritation, non-porous, easily shaped and tolerated with comfort for periods of weeks or months

Acrylic materials, which fulfill these criteria have found application in several fields In addition to dental and maxillofacial uses, acrylics have been employed in arthroplasty, spine stabilization and cranioplasty, for plombage in pulmonary tuberculosis, as experimental aortic valves, as orbital implants and as corneal lenses In 1945 Erich[4] described the use of veronite (a dental acrylic material) in the treatment of chronic laryngeal stenosis

The Acrylics

The acrylics (acrylic resins) constitute one class of plastics, a large group of organic substances, wholly or in part synthetic, which can be molded into solid articles retaining their shape indefinitely at ordinary temperatures The components of plastics have resinous characteristics, *i e*, they lack a visible crystalline structure because of the size and complexity of their molecular structure Resinification may occur by condensation (a chemical reaction which eliminates H_2O or some other simple compound) or by polymerization, in which high-molecular compounds are formed by consecutive joining of unsaturated molecules

Acrylic resins are examples of polymers of acrylic acid and its derivatives The acrylates were first produced commercially in the late 1920s, in 1936 methyl methacrylate resin was introduced as "Plexiglas" by the Rohm & Haas Company, and as "Lucite" by E I duPont de Nemours and Company

Methyl methacrylate, the acrylic which has been most used in medical work, is colorless, transparent, and may be highly polished, with a surface comparable in hardness to copper or brass It is not affected by aqueous solutions of inorganic salts or by dilute acids or alkalies, but alcohol may cause softening and "crazing" The optimum temperature for molding is 245° to 310° F , at higher temperatures the formation of small bubbles will destroy the smoothness of the surface Holes may be drilled with ordinary twist drills, with care to avoid over-heating from friction Particularly important is the high biologic tolerance for the material, which elicits a minimum of inflammatory response in living tissues

Acrylic Molds

Solid acrylic molds are usually prepared in the dental laboratory by casting, in the same manner as dental plates, from a previously prepared model formed by the use of dental modeling compound and base plate wax Chemically, the process consists of introducing a "syrup" of partially polymerized monomer into the plastic mold, solidification occurs as polymerization becomes complete Special "plasticizers" may be used as agents to complete the polymerization

Frequently a rubber mold which has been previously worn may be used as a starting point in preparation of the model which is sent to the dental laboratory As suggested by Robb,[12] barium sulfate powder is incorporated in the mixture at the time of casting if a radio-opaque mold is desired, the opacity of methyl methacrylate alone is about the same as that of soft tissue

Hollow acrylic molds may be made by drilling a solid mold lengthwise, but are prepared more quickly and more conveniently by heat-shaping of acrylic tubing, which is supplied in several sizes with a wall thickness of one-sixteenth inch Heat-shaping may be accomplished by the same general methods used in shaping glass, with due precaution to avoid overheating. An ordinary alcohol lamp with a small flame serves well for this purpose. Acrylic tubing may be cut with a jeweler's saw or a small hack-saw, and the ends smoothed with the finest grade of sand-paper, followed by "crocus cloth" and a final buffing with pumice.

Core-Molding

The objectives of core-molding may be: *1.* to prevent chronic stenosis (a) in cases of recent trauma with fracture of laryngeal cartilages, rupture of tracheal wall or dislocation of arytenoids, or (b) following operation, if large portions of cartilage have been removed, as in the more extensive types of partial laryngectomy,[8-11] in laryngofissure for extensive papillomatosis,[12] and in arytenoidectomy for bilateral paralysis[13]; *2.* To accomplish and maintain dilatation in cases where chronic stenosis has already occurred. Relief of stenosis may be achieved by plastic procedures with excision of fibrous tissue and cartilage, but stenosis will recur unless molds are used to maintain the lumen until the tendency for contracture has diminished (several weeks or months). In many cases, the use of molds alone, without preliminary operation except for tracheostomy, will be successful.

INJURIES OF THE LARYNX AND TRACHEA

The management of these cases, which are encountered with increasing frequency, has recently been comprehensively reviewed by Holinger and Johnston.[5] In cases of recent trauma, an acrylic mold corresponding in size to the injured larynx should be inserted as promptly as possible, preferably at the time of tracheostomy, and left until healing is complete. The mold will function as an internal splint, aiding in restoring displaced fragments of cartilage to their normal position. Even though some degree of perichondritis may occur as a result of the injury, this will not be increased or unduly perpetuated by the presence of the mold if the proper size and shape are chosen. Systemic antimicrobial treatment, preferably based on cultures and sensitivities, may be used.

Examples of molds used for this purpose are shown in Fig

1-b and Fig 1-c Incised wounds (windshield, attempted suicide, etc) involving the laryngeal cartilages are treated in a similar fashion if fragmentation of cartilage has occurred

PREVENTION OF POSTOPERATIVE STENOSIS

In extensive types of partial laryngectomy, with or without skin graft, a foam-rubber mold covered with latex is inserted at the time of operation and left for about ten days, usually being anchored with two through-and-through heavy sutures of stainless steel wire If progressive narrowing of the airway should occur thereafter, an acrylic mold should be inserted before the lumen becomes inadequate and left until epithelialization is complete and the tendency for further contracture diminished Figi[6] has advocated the routine use of an acrylic mold in such cases An acrylic mold is routinely inserted for two or three days following intralaryngeal arytenoidectomy according to the technique of Thornell[13]

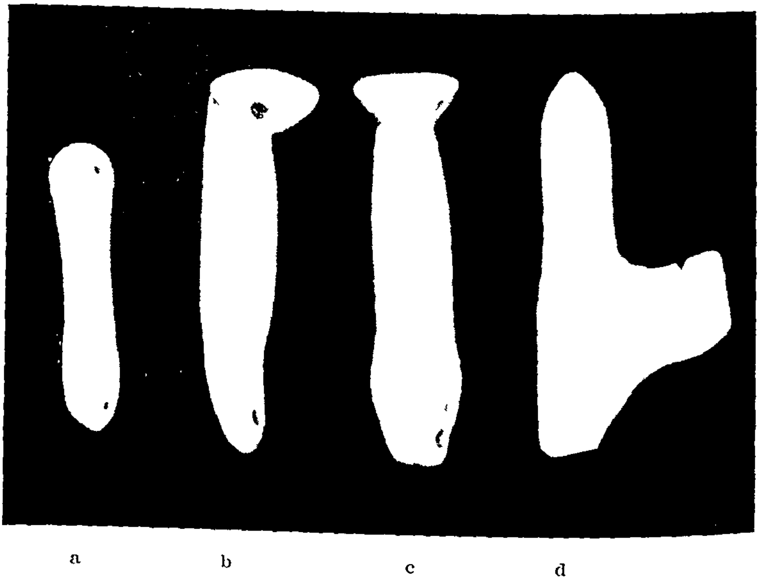

Fig 1 Solid acrylic molds (a) Was used in the case illustrated in Fig 2 (shaped to be self-retaining) (b) and (c) have been used in treatment of both recent traumatic stenosis and chronic stenosis (d) shaped for introduction through an enlarged tracheal fistula was used in the case illustrated in Fig 3

CHRONIC STENOSIS OF LARYNX AND UPPER TRACHEA

Initially, the degree and extent of the stenosis must, of course, be evaluated by indirect and direct laryngoscopy, occasionally by "retrograde" laryngoscopy, and usually by Roentgen study including lateral films for best demonstration of the residual airway, planigrams are at times informative and films made following instillation of iodized oil may be helpful Unless the stenosis is of such degree as to require a plastic operation, treatment should begin with increasing sizes of rubber molds (usually sections of catheter) or polyethylene tubing, changed at intervals of four to seven days to minimize inflammatory response Attempts at vigorous dilatation and insertion of large molds initially may result in soft tissue and perichondrial inflammation sufficient to delay further treatment Obviously, in cases where high tracheostomy

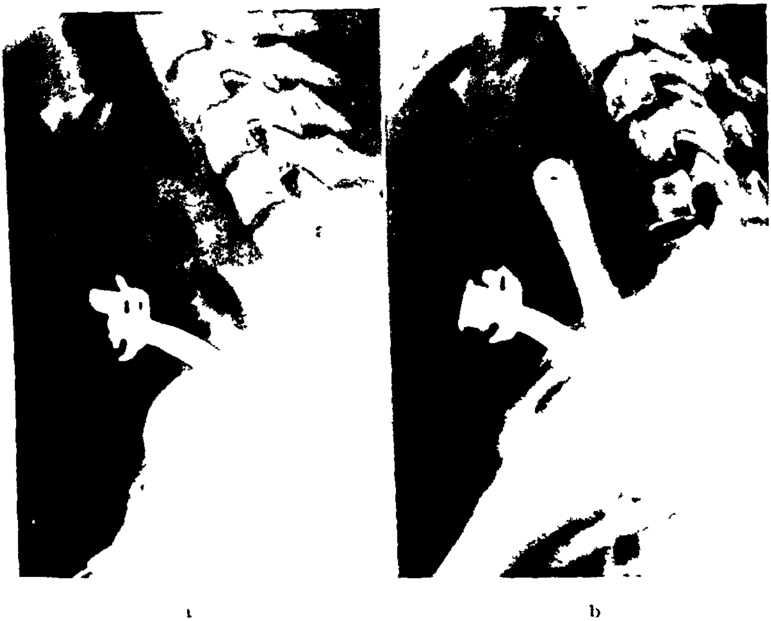

Fig 2 (a) Nearly complete atresia of upper trachea in a girl of 12 years the result of injury (fall on sharp edge of tin can) 6 years before (b) Solid acrylic mold (28 f) introduced after progressive dilatation with indwelling rubber molds (8 f to 28 f) The acrylic mold was removed after 6 weeks with little evidence of subsequent contracture and decannulation was accomplished after a test period of ten weeks No further treatment required

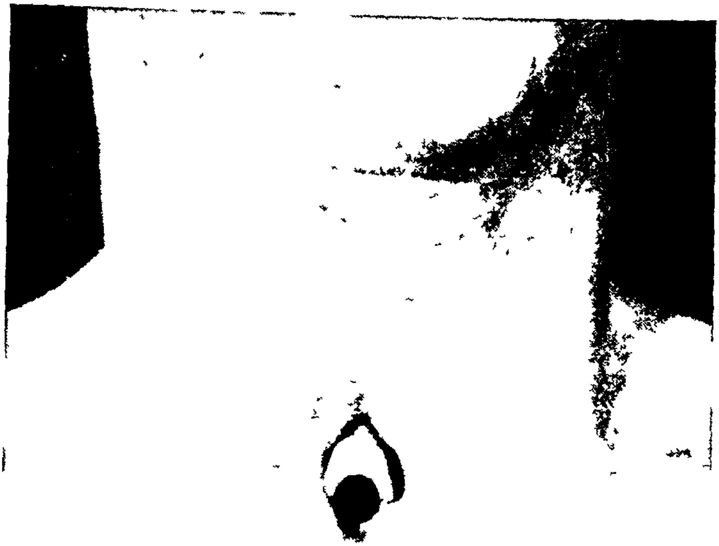

Fig 3 Solid acrylic mold of special shape (see Fig 1-d) in a case of atresia of upper trachea due to crushing injury (auto accident) four weeks before first seen Preliminary treatment (six weeks) with increasing sizes of rubber molds (f to 34 f) The mold shown was then worn continuously for twelve weeks decannulation two months later No recurrence of stenosis in past six years Shape of mold allowed daily changing of tracheal cannula

was an etiologic factor, a lower tracheostomy should be performed before treatment is started, in some cases, however, the upper fistula may be kept open and used to anchor the successive sizes of molds, and the subsequently used acrylic mold (see Fig 5-b)

After accomplishing dilatation to the desired lumen size (average 32 to 36 fr for the adult female or 36 to 40 fr for

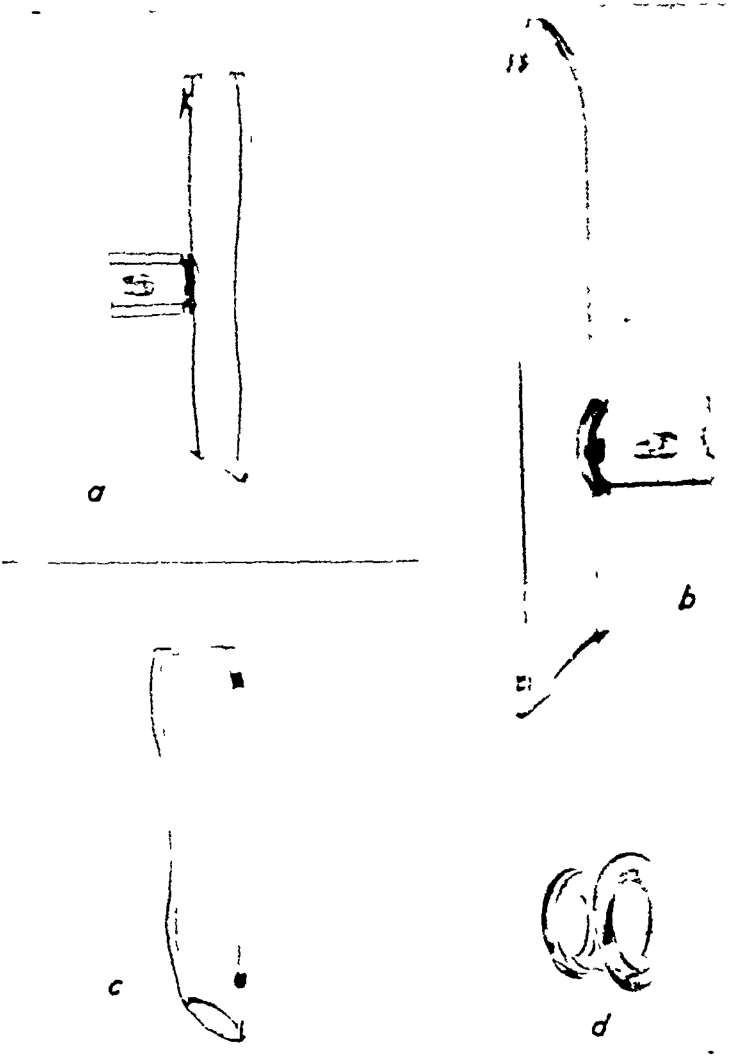

Fig 4 Hollow acrylic molds heat-shaped from acrylic tubing (a) and (b) were used in a child and an adult in which lower tracheostomy was required as a preliminary to treatment of chronic subglottic and upper tracheal stenosis The separate short acrylic 'post' lies in the fistula of previous tracheostomy being anchored to the mold by heavy silk string (c) is a hollow acrylic mold shaped to be self-retaining (d) is an acrylic 'button' (Moore) useful in preventing contracture of the tracheal stoma following laryngectomy

the adult male), an acrylic mold of the same size is introduced This may be done by, *1* direct or suspension laryngoscopy, using a special forceps to grasp the upper end as the entering portion is advanced through the larynx, or *2* drawing into place by axis-traction, using a heavy braided silk string loop passed through the hole in the entering end of the mold and manipulated through the tracheal fistula A second loop of string through the upper end of the mold provides for counter-traction to maintain alignment In the case of hollow molds, a third method may be used First the mold and then a bronchoscope is introduced over the steel shaft of a previously inserted small bougie, the bronchoscope may then be used to push the mold into place Less frequently, if there is a large anterior defect in the wall of the airway, the mold may be

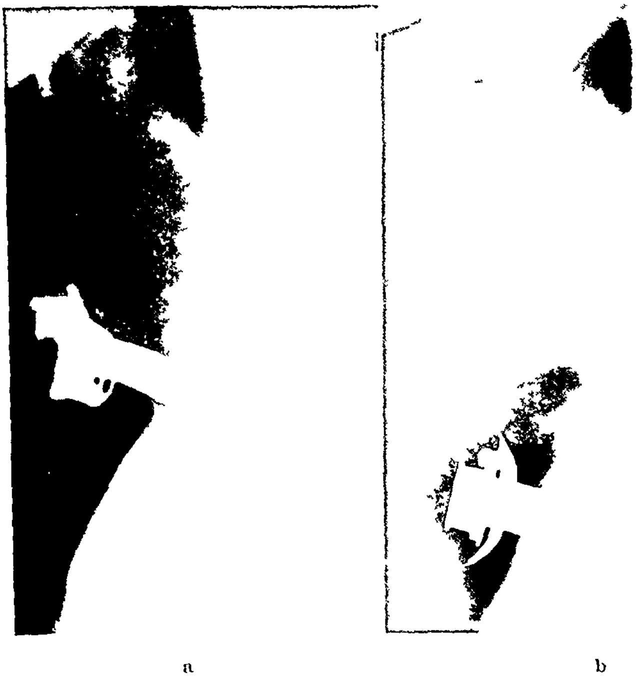

Fig 5 (a) Marked glottic subglottic and upper tracheal stenosis due to crushing injury (auto accident) (b) the hollow acrylic mold shown in Fig 4-b is shown in place having been introduced following progressive dilatation with rubber molds The anchoring acrylic post lies in the uppermost (previous) tracheal fistula

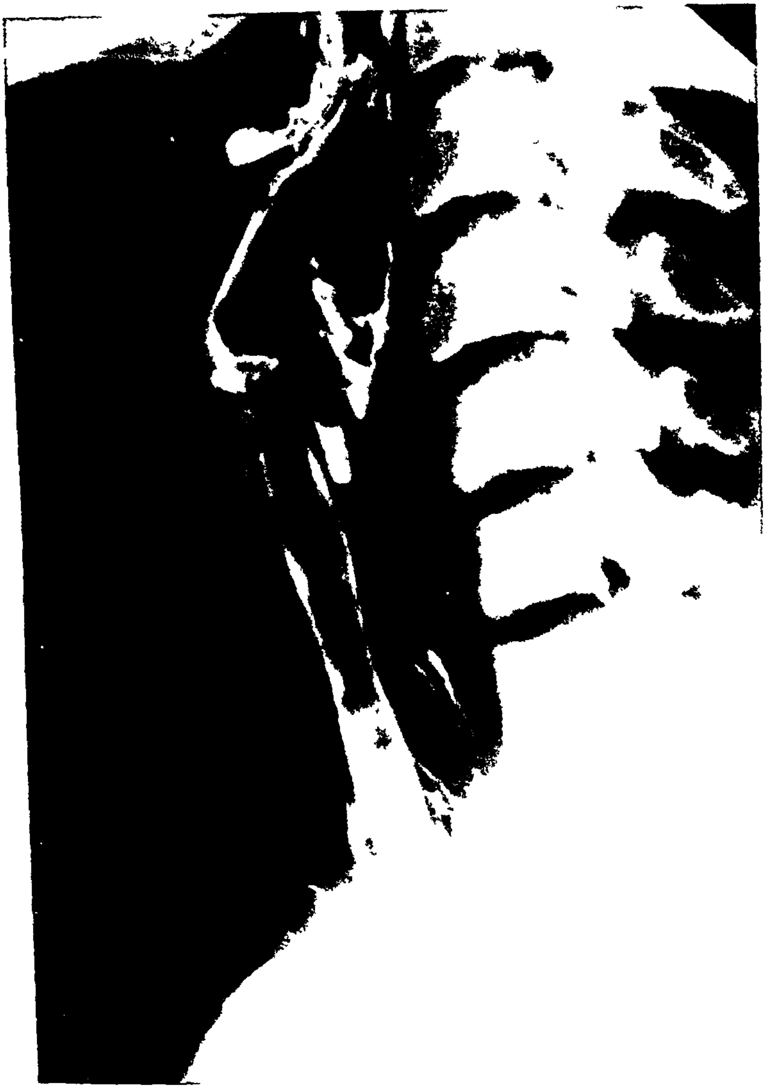

Fig 6 Use of contrast material (Dionosil oily) to demonstrate relations of a hollow acrylic mold in a case of upper tracheal stenosis Only the inner surface of the mold is coated Position of upper end of mold just below glottic level is well shown The outer end of the tracheostomic fistula is outlined With cannula in place and occluded patient has an excellent voice

introduced from below Laryngostomy is rarely required for introduction of a mold

Molds may be kept in place, *1* by shape, expanded portions at the upper and lower ends preventing movement in either direction (see Figs 1-a, 2-b, 4-c, and 6), *2* by anchoring by means of a loop of braided silk brought from the lower end of the mold through the tracheal fistula to a section of rubber or acrylic externally (tying to the cannula or its neck plate is not favored because this interferes with frequent changing of the cannula), or *3* by use of a short "post" resting in the uppermost tracheal fistula and anchored against the surface of the mold by heavy silk ties (see Figs 4-a, 4-b and 5-b) The latter method is useful in cases where previous "high" tracheostomy requires tracheostomy at a lower level Specially shaped molds (see Figs 1-d, 3) are inserted from below and have a protruding portion shaped to the convexity of the tracheal cannula This prevents displacement and at the same time allows the patient to change the cannula daily

The degree of reaction to presence of the mold may be determined by indirect or direct laryngoscopy Increasing edema of the arytenoid eminences, increasing discomfort on swallowing, and tenderness, swelling or redness externally, indicate a disproportionate inflammatory response to a mold which is too large, or reactivation of perichondritis, in which case the mold should be removed and a smaller one introduced until resolution occurs If no reaction is observed after two weeks, the mold will probably be tolerated for an indefinite period

The usual interval for use of the acrylic mold is four to six months, although this depends to some extent on the degree of stenosis present initially Hospitalization is not required after the first two or three weeks, but frequent out-patient observation is desirable A test period of several weeks after removal of the mold, before decannulation, will determine whether there is any appreciable tendency for recurrence of stenosis

Other Uses of Acrylic Materials

The acrylic "button" as described by Moore[10] is a useful device for preventing contracture of the tracheal stoma following laryngectomy. As shown in Fig. 4-d, the button has an inner flange small enough to allow removal, cleaning and reinsertion by the patient, but large enough to prevent coughing out. The outer flange lies closely against the skin adjacent to the stoma, and is large enough to prevent inadvertent pushing into the trachea with reinsertion.

The "button" may be shaped from heated acrylic tubing by lathe, or by a simpler method in which the flanges are formed by using a length of wooden doweling slightly smaller than the internal diameter (usually three-eighths inch) of the tubing. The dowel is inserted through the tubing as the end is heated to the softening point. Then, with tubing and dowel both held perpendicular to and in contact with a smooth metal surface, the tubing is pushed down firmly to expand the end into a circular flange of the desired size. For the patient who has been wearing a No. 7 tracheal cannula, the diameter of the inner flange should be about 15 mm., and that of the outer flange at least 18 mm. Alterations in diameter of the inner flange may be required for proper fitting in the individual case.

Plastic material (acrylic ?) has been used by Alonso[1] in the treatment of anterior web of the glottis to prevent adherence and recurrence of synechia after endoscopic division. A thin semicircular plate is held in position by sutures brought out above and below the thyroid cartilage until epithelialization is complete.

In the operation recently described by Conley et al,[3] a specially shaped prosthesis attached to a plastic tracheal cannula serves to divert air from the trachea through a mucosa-lined channel into the pharynx for voice production.

Another special variety of acrylic mold used by Erich[2] encircles the outer portion of the tracheal cannula, which is provided with fenestrae. A hollow portion of the mold, projecting upward toward the glottis and communicating with the fenestra below, allowed breathing and speaking in a case in which decannulation could not be accomplished.

SUMMARY

The properties of "acrylic" (methyl methacrylate) which account for its usefulness in laryngology may be summarized as follows: *1.* High biologic tolerance; absence of tissue reaction is such that molds may be worn for weeks or months with comfort, and without odor or necessity for removal for cleaning. The tendency for contracture following removal is minimal; *2.* Adaptability; by casting of solid molds or heat-shaping of acrylic tubing, apparatus best suited to the given case may be prepared without great effort or inconvenience. The ease with which self-retaining molds may be prepared allows daily changing of the tracheal cannula which, in itself, contributes much to cleanliness of the tracheal fistula and adjacent structures. *3.* Physical characteristics; the absence of softening or change in shape is a desirable feature, and the hard, highly polished surface favors disappearance of granulation tissue and healthy epithelialization.

Flexible molds (rubber or polyethylene) are more easily introduced, but in many instances must be kept in place by retaining sutures or strings. Polyethylene is undobtedly equal to acrylic in tissue tolerance, but it is not easily shaped and, being of softer consistency, lacks optimum smoothness of surface.

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AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY HOME STUDY COURSES

The 1959-1960 Home Study Courses in the Basic sciences related to ophthalmology and otolaryngology, which are offered as a part of the educational program of the American Academy of Ophthalmology and Otolaryngology, will begin on September 1 and continue for a period of ten months Detailed information and application forms can be secured from Dr William L Benedict, executive secretary-treasurer of the Academy, 15 Second Street S W, Rochester, Minn Registration should be completed before August 15

GIANT-CELL TUMOR OF THE SINUSES*†

LUDWIG A MICHAEL, M D ,
Dallas, Tex

Giant-cell tumors of bone present several controversial features their origin is not clear, their benign character is subject to increasing doubt, and their response to treatment uncertain

PATHOLOGY

Most authors agree in classifying them as true neoplasms, though at times they have been thought to be chronic inflammatory lesions or results of trauma Jaffe, *et al*,[7] regard giant-cell tumor as "a neoplasm of a definite kind, arising apparently from the undifferentiated supporting connective tissue of the marrow" Its cytology is typical The giant cell is the obvious feature from which its name is derived, but the above authors point out that the stromal cells should not be forgotten, as they are really the more significant, indeed, the giant cells are believed to form from fusion of the stromal cells

Grossly, the lesion involves the epiphysis and adjacent metaphysis of long bones Further growth and extension are influenced by factors such as trauma by pathological fracture with breakthrough of the periosteum, or the trauma of therapy Most of the cases fall in the 20 to 40 age group, however, Geschickter and Copeland[5] note that the age incidence of giant-cell tumors of the skull is one decade younger than in the long bones The majority of the tumors are found about the knee, other sites are the other long bones, vertebrae, anterior portions of the mandible, or maxilla

Recent literature has shown increasing skepticism of the

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*Read at the meeting of the Texas Ophthalmological and Otolaryngological Society Houston Tex Dec 5 1958

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use of the term "benign" as it is applied to this lesion Much evidence has accumulated which points to a course other than benign, not only after therapy which is presumably incomplete in eradication of the growth, but perhaps *de novo* Jaffe, *et al*,[7] introduced grading of this tumor according to cytologic features Grade I tumors show typical stromal cells, not densely compacted, uniform in size, without abnormal mitoses Grade II tumors show more atypical stromal cells, but they are not yet quite frankly malignant Nuclei vary in size and shape, some are multiple, and mitotic figures are frequent and even abnormal Grade III tumors, though a small group, are frankly malignant and show sarcomatous features This group more frequently contains tumors which were originally Grade I or II tumors which have become more aggressive over the years Such a change may either follow irradiation or curettage, or be inherent in the tumor from the beginning A large group of tumors, formerly called giant-cell tumors, are removed from this category and called giant-cell variants These include osteofibromas, ossifying enchondromas, or xanthofibromas Dahlin, *et al*,[2] called attention to the confusion of giant-cell tumor with nonosteogenic fibroma where the essential difference lies in the fibroblastic activity of the latter This classification results in a strict delimitation of giant-cell tumors, a designation which, according to some authors, is too sharply circumscribed[8] At present it seems best to call the lesion giant-cell tumor, benign or malignant, as the circumstances warrant

DIAGNOSIS AND TREATMENT

The X-ray appearance and course of these lesions are so characteristic to Brailsford[1] that he feels biopsy is unnecessary and may be disturbing to the lesion At the other extreme, some feel that a punch biopsy is inadequate to study the lesion and advise removal of enough material for a conclusive pathological diagnosis

The different forms of treatment used have not been evaluated carefully enough to point to any as definitive The British, on the whole, recommend X-ray therapy as the treatment of choice, and many American authors subscribe to this view, on the other hand, in view of recent reports of the effects of radiation, caution must be exercised There is much evidence that a malignant transformation may follow the use of Roentgen-ray therapy Sabanas, *et al*,[11] collected a series of seventeen cases of sarcoma following radiation, of which nine occurred at the site of giant-cell tumors of bone The average latent period between radiation and onset of sarcoma was over ten years

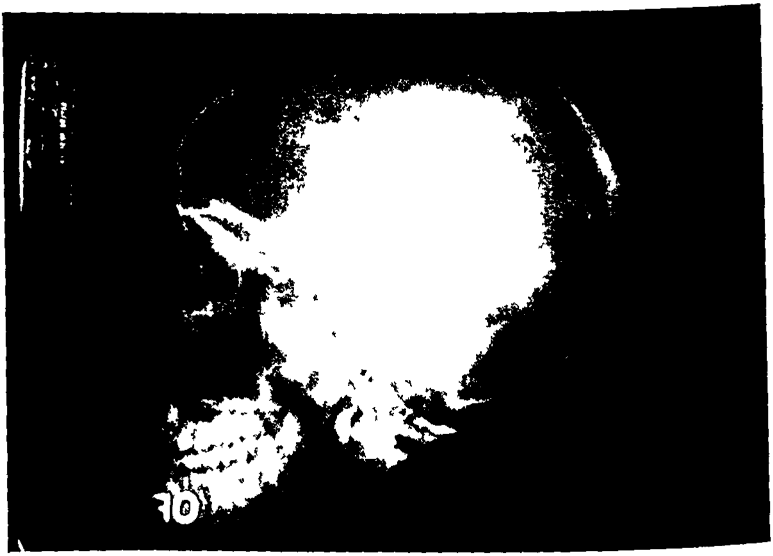


Fig 1 X-ray showing clouding of sphenoid

Surgical treatment includes radical surgery such as amputation or wide excision, and more conservative methods such as curettage and cauterization Excision in weight-bearing areas might lead to loss of function, while in other areas it may not be feasible because of inaccessibility For such tumors, curettage, with or without cautery, and packing with autogenous bone chips can be used Another method is the combination of radiation and surgery, where a course of radiation is given to reduce the vascularity of the tumor and if necessary curettage is then applicable

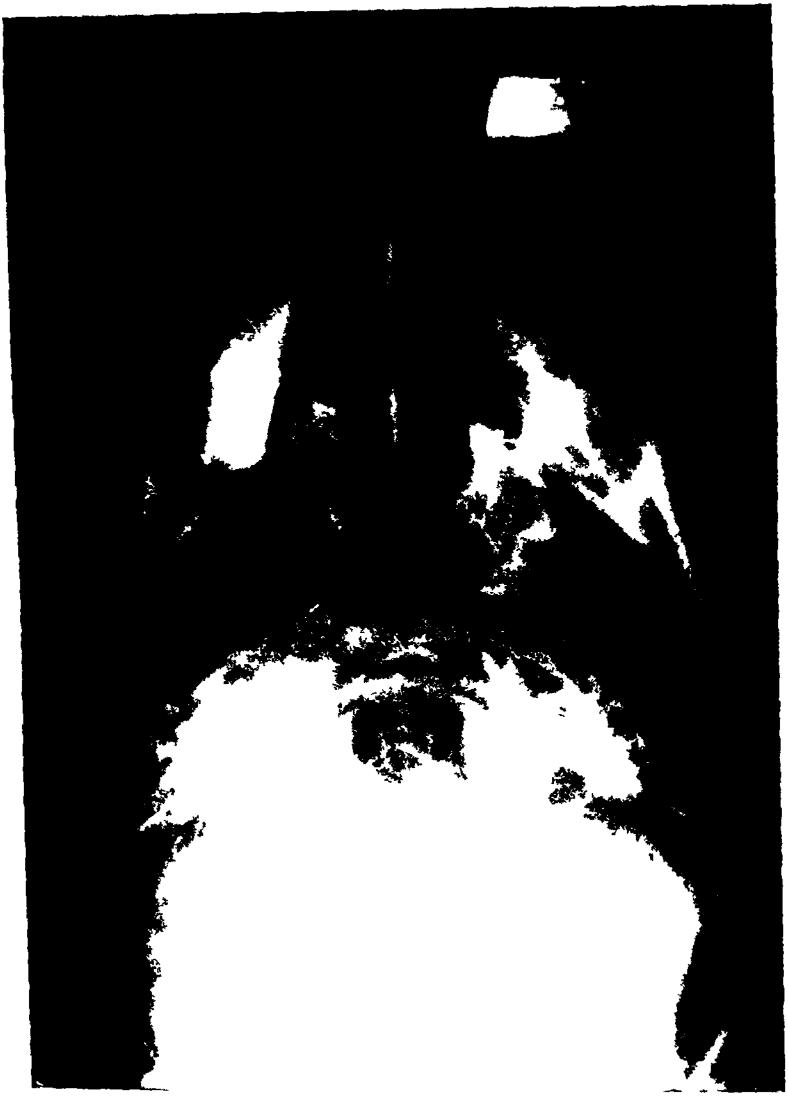


Fig 2 X-ray showing mass on right with obliteration of landmarks of base of skull

PROGNOSIS

Prognosis should be guarded because of the tendency to recurrence and possible malignant transformation Although it was once believed that these tumors were always benign and remained so, that point of view seems no longer tenable in the face of reports of malignant transformation and of instances of aggressiveness of the tumor following radiotherapy and repeated curetting.[8,11,12] In a relatively large series of close to 100 cases it was found by Dahlin, *et al.*, that one-half of giant-cell tumors recur after conventional curettage, and ten per cent undergo sarcomatous transformation, some perhaps triggered by radiation therapy.

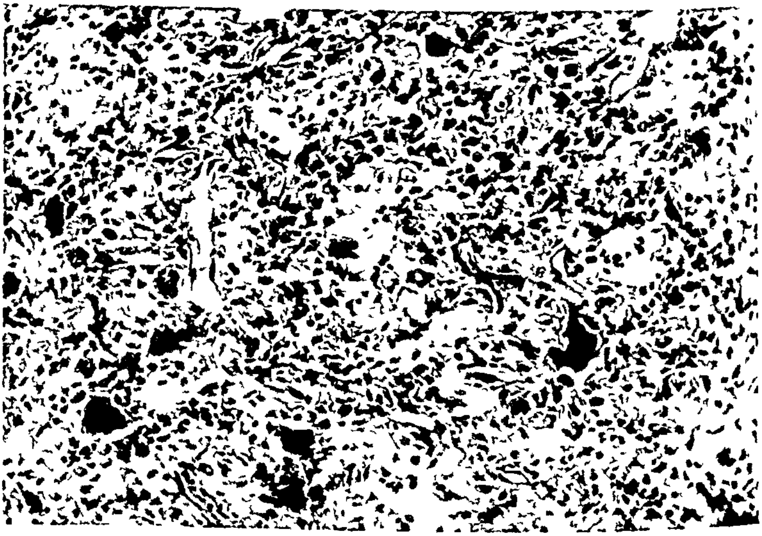
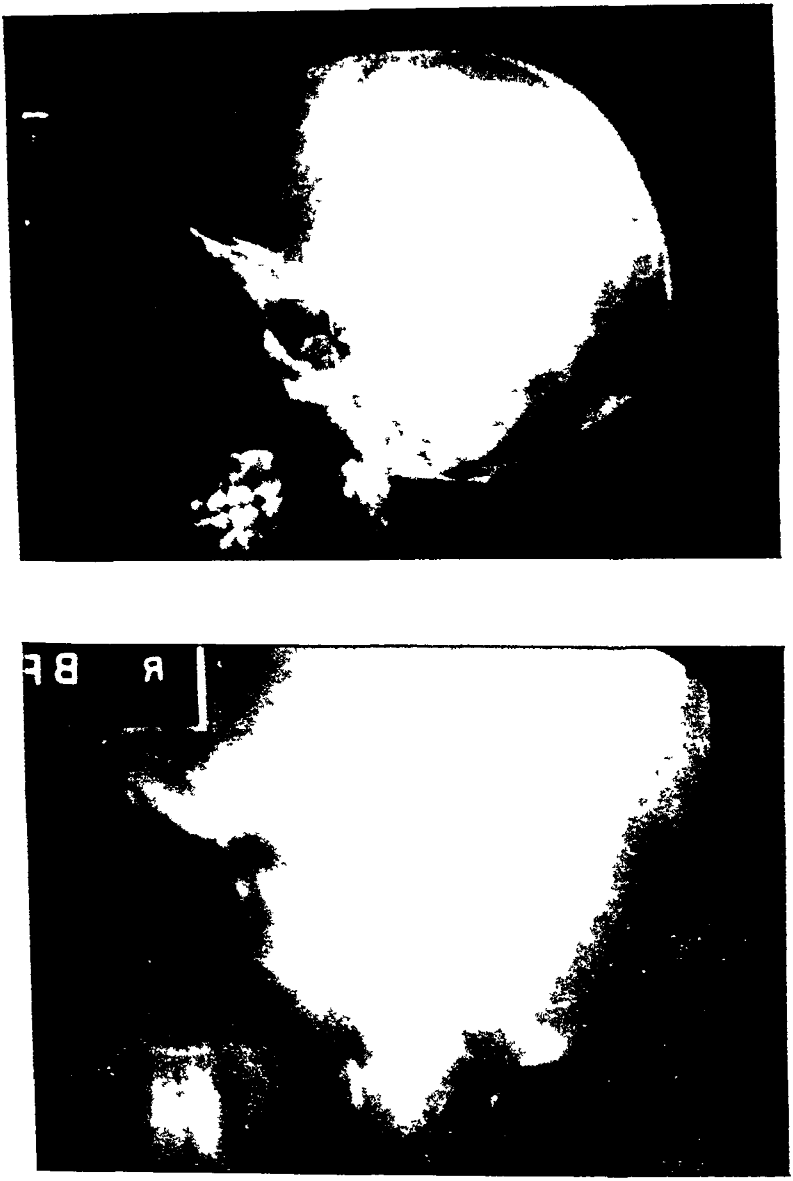


Fig. 3. Giant-cell tumor of bone (X275).

INVOLVEMENT OF THE SINUSES

Giant-cell tumors of the sinuses are relatively rare and not many have been reported. The diagnosis does not readily suggest itself when found in this location. Geschickter,[4] in a series of 39 benign primary cranial bone tumors found only four giant-cell tumors. Since they are so rare in the sinuses the diagnosis should be made by the removal of tissue for study. Presenting complaints are not characteristic and depend on the site. Proptosis has been common with ethmoid and sphenoid involvement, and pain from nerve involvement has been reported.

Wattles,[13] reviewing the literature in 1937, reported seven



Figs 4 5 Lateral X-ray and 8 cm stratagraph showing calcification in the sphenoid sinus cases in the ethmoid and added one Handousa[6] reported twelve cases, eight of which were in the superior maxilla, three in the ethmoid, and one in the sphenoid In his series, most patients were females and in the second and third decades of life His cases did not do well on radiation, and a preference for excision was expressed

Echols[3] reported a case in the sphenoid with intracranial extension and involvement of the optic chiasma, petrous ridges, middle fossae, and extending to the palate anteriorly and down to the retropharyngeal area Both surgery and irradiation were used, with a fatal termination

Permer,[9] in reviewing the literature in 1954, found reports of thirteen cases in the ethmoids and four in the sphenoids To these he added three cases, one each in the maxillary antrum and sphenoethmoid and another in the orbital roof One of these, in which the tumor was excised, did best Ramamurthi, *et al*,[10] reported a case of giant-cell tumor of the sphenoid in which extension produced intracranial symptoms After attempted removal, progression of symptoms was noted, but deep X-ray therapy was refused by the patient Geschickter and Copeland[5] express a preference for the use of radiation in lesions of the skull, when recurrence following surgery may prove fatal

To these reports the present author adds one case of giant-cell tumor originating in the sphenoid, treated by X-ray therapy, with remission of symptoms and evidence of healing

CASE REPORT

Mrs C B, a 16 year old white married female, was first seen for ear, nose and throat consultation on September 6, 1951 An ophthalmologist referred her for investigation of the presenting complaint of proptosis of the right eye Her first symptom referable to the present illness was brief periods of numbness over the right infra orbital area two years previously, accompanied by slight headaches In August, 1951, she noticed slight proptosis of the right eye accompanied by more severe headaches These symptoms gradually increased There was no complaint of nasal discharge, obstruction or bleeding, a slight hearing loss had been noted in the right ear for many years, and there was no change in this symptom

Physical examination revealed a marked proptosis of the right eye Nasopharyngoscopy revealed slight encroachment or enlargement of the anterior lip of the torus on the right Direct antroscopy through a trocar revealed a clean but shallow right antrum X rays showed "a large area of bone destruction extending into the middle fossa and obliterating the foramen ovale, foramen spinosum, foramen lacerum and extending back almost to the foramen magnum. The destruction extends into the squamous portion of the temporal bone. The margins of the bone are smooth; the edges show no motheaten appearance but are of a normal architecture completely to the edge of the destroyed portion. The area of destruction involves the posterior portion of the floor of the orbit."

On September 14, 1951, at Baylor University Hospital, Dallas, under general anesthesia, the right antrum was entered through a Caldwell-Luc approach. The antrum was found to be normal except that the posterior wall was bulging markedly forward. The bone in this region was intact but thin. When this bone was removed, a smooth, firm encapsulated mass presented. Any manipulation of this mass resulted in severe bleeding. The capsule was entered and thick cheesy material exuded. Part of the wall was removed for biopsy, the bleeding controlled by cautery, and the operation terminated, leaving the labial incision open.

The biopsy was reported as: "The tissue represents a tumor consisting of a moderate number of multinucleated giant cells surrounded by a loose stroma containing large numbers of round and spindle cells. The giant cells are ovoid shape, with homogeneous, opaque cytoplasm and contain from six to fifty small oval nuclei. The relative number of the giant cells varies from one place to another. The cells between the multinucleated cells include a large number of foamy macrophages, lymphocytes and spindle cells with oval vesicular nuclei. In some focal places the macrophages contain golden granular particles of hemosiderin. The supporting fibrovascular stroma is overshadowed by the cellular elements and the blood vessels are small and composed of an internal lining of endothelial cells and a thin layer of collagen. No mitoses are seen, and no osteoclastic activity can be demonstrated. The pathological diagnosis is benign giant cell tumor of bone."

Because of the extent of the tumor no further surgery was attempted. The patient was given external irradiation through a right PA 6 cm size port and a right lateral 7 cm size port at 250 KV/15 Ma/½ mm Cu/1 mm Al/50 cm t.s.d. with minimum tumor dose of approximately 1600 r, maximum skin dose 3600 r in 12 days. Two months later this was repeated; three months later (February, 1952), the third series of external irradiation treatments was given to the tumor through a single right temporal area 5 cm in size with six equal daily fractions which added 600 r to the minimum tumor dose. The patient did very well. Her eye returned to normal, all symptoms of the lesion receded, and only an oroantral fistula persisted and required occasional irrigation of the antrum through this fistula. One attempt to close the fistula failed, but a second attempt in April, 1956, succeeded. In May, 1955, X-rays revealed "in the lateral view, a particularly excellent demonstration of calcification within the sphenoid sinus. This would indicate that the previous impression of the giant cell tumor having involved the sphenoid sinus is true. The 8 cm cut in the lateral stratagraph shows this calcium within the sphenoid sinus well."

The patient was last seen in May, 1957, and was well.

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UNIVERSITY OF ILLINOIS DEPARTMENT OF SPEECH

As a result of several years of clinical and experimental research, a multiple-choice word list suitable for testing auditory, visual, and combined auditory-visual intelligibility has been developed at the University of Illinois Hearing Center The recorded auditory test has been found to give rapid and reliable estimates of listening errors Commercial disc and tape recordings are being prepared for distribution to interested persons Personnel involved in the development of the test include Charles Hutton, E Thayer Curry, and Mary Beth Armstrong

THE INTERMITTENT EAR OCCLUSION TEST[*]

A Method of Differentiating Sensations of Hearing and Feeling

KURT TSCHIASSNY, M D ,

Cincinnati, Ohio

Patients with monaural anacousis (complete hearing loss) are frequently unable to differentiate between the acoustic and tactile character of the sensation produced by a vibrating fork on the skull

Our three cardinal tuning fork tests are frequently not informative for the following reasons

In the Rinne test it may be easy to confuse the pseudo-negative with the negative Rinne even with masking of the opposite ear, since this maneuver eliminates the acoustic but not the tactile component of the sensation produced by a vibrating tuning fork

The Schwabach test is not usefull since it provides information concerning only conditions in the opposite good ear Sound perception may be lengthened, shortened or indifferent depending upon whether there is a conductive, perceptive or no defect at all present

The significant lateralization toward the "good" ear in the Weber test is frequently missing in these cases, probably due to some as yet unexplained psychesthetic factors

The following procedure was found to be helpful in identifying unilateral complete deafness and in clarifying the situation wherein the patient is unable to tell whether he "hears" or "feels" the vibrations

A vibrating tuning fork, preferably 250 or 500 c p s , is placed on the patient's vertex or one of his mastoids The

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[*] From the Department of Otolaryngology College of Medicine University of Cincinnati

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examiner places a finger over one of the patient's external meatuses Now he alternately occludes and opens the orifice This maneuver when performed in an ear with hearing by air-conduction is accompanied by an acoustic "off-and-on" sensation, distinctly perceived by the patient This phenomenon can be clearly explained in terms of the classic Weber experiment The same maneuver, however, when exercised on an ear without hearing by air conduction does not produce any fluctuation of sound, since this sensation depends upon acoustic (otic) but not on tactile factors, therefore, the sensation is reported as a steadily diminishing but not fluctuating sound, since the perception is provided by the opposite, unmanipulated ear

The rhythm of the "off-and-on" sensation is synchronous with the movements of the finger As a rule we noticed inward movement to be associated with the "on" sensation while the opposite feeling appears with the release of pressure, however, the reverse effect was obtained upon extremely strong pressure, probably a manifestation of the Gellé principle This explanation is based on self-observation confirmed by others

This directional reversal of rhythm is mentioned in order to avoid confusion when the maneuver is first tried It is the "off and on" sensation, not the directional character of its rhythm, which indicates the presence of hearing

This test, repeatedly performed by the author, was found to be helpful in differentiating tactile from acoustic sensations produced by a vibrating fork on the head

It is readily understood that the "fluctuation phenomenon" requires hearing by air-conduction and the presence of adequate ambient noise, therefore, the phenomenon may be absent when sought for in a sound-conditioned room or in patients with severely impaired air conduction, such as in advanced otosclerosis, adhesive processes, radical mastoidectomy, etc The procedure was demonstrated at the staff meeting of the Department on October 4, 1958 Further studies on a larger scale in cooperation with other members of the Department are in progress

101 Louis Avenue

PROGRAM FOR THE 108TH ANNUAL MEETING AMERICAN MEDICAL ASSOCIATION

Section on Laryngology, Otology and Rhinology

Atlantic City, June 8-12, 1959

(Rather than assigned discussers each paper, except those of the Guest of Honor and the Chairman, will be followed by an open discussion period, questions and comments from the floor are encouraged)

Tuesday, June 9—2 P M

Prof Dr H H Naumann Wurzburg, Germany—
Intravital Observations of the Nasal Mucous Memberane (Film)

George M Coates, M D , Philadelphia, Pa —
Address of Guest of Honor

Gordon D Hoople, M D , Syracuse, N Y —
Modern Otolaryngology

F W Davison, M D , Danville, Pa —
Laryngeal Obstruction in Children

Ben T Withers, M D , Houston, Tex —
Facility in T&A Management Conclusions from 2400 Consecutive Cases

Joseph H Ogura M D , St Louis, Mo —
Cancer of the Pharynx, Larynx and Upper Esophagus, Surgical Aspects

Business Meeting

Report of Section Delegate to AMA House of Delegates—
Gordon F Harkness, M D , Davenport, Ia
Dean M Lierle, M D , Iowa City, Ia , Alternate

Report of Section Representatives to Board of Governors of American College of Surgeons—
Roderick Macdonald, M D , Rock Hill, S C
Edley H Jones, M D , Vicksburg, Miss
John J Conley, M D , New York, N Y

Report of Nominating Committee—
F W Davison, M D , Danville, Pa
Louis E Silcox, M D , Philadelphia, Pa
John D Singleton, M D , Dallas, Tex

Wednesday, June 10—2 P M

J W HAMPSEY, M D , Pittsburgh, Pa —
Current Concepts of Etiology and Management in Otolaryngic Allergy

VICTOR R ALFARO, M D , Washington, D C
Address of Section Chairman

HENRY S KAPLAN, M D , San Francisco, Calif —
New Horizons in the Radiotherapy of Malignant Disease

JOHN A KIRCHNER, New Haven, Conn —
Facial Bone Injuries

M R HIMALSTEIN, M D , Bay Pines, Fla —
Obliterative Frontal Sinus Surgery Using Gelfoam

J M RAVID, M D , New York, N Y —
Malignant Melanoma of the Nose and Paranasal Sinuses, and Juvenile Melanoma of the Nose

Wednesday Evening, June 10—6 30 P M

Social Hour and Dinner Honoring the Guest of Honor of the Section, Dr George M Coates

Thursday, June 11—2 P M

JOSEPH L GOLDMAN, M D , and HARRY ROSENWASSER, M D , New York, N Y —
Current Concepts of the Management of Otitic Infections

MERLE LAWRENCE, Ph D , Ann Arbor, Mich —
Ear Physiology

EDWARD W HARRIS, M D , Columbus, O —
Symptoms Referable to the Eustachian Tube

GEORGE KELEMEN, M D , Boston, Mass —
Maternal Diabetes and Congenital Deafness

JOSEPH SATALOFF, M D , Philadelphia, Pa —
Stapes Mobilization with Long-Standing Otosclerosis

HOWARD P HOUSE, M D , Los Angeles, Calif —
Polyethylene in Middle Ear Surgery

PACIFIC COAST OTO-OPHTHALMOLOGICAL SOCIETY

The Annual Meeting of the Pacific Coast Oto-Ophthalmological Society will be held May 3-7, 1959, at Hotel Riveria, Las Vegas, Nevada.

A very superior Scientific Program has been arranged for the Las Vegas meeting. We have an outstanding group of guest speakers in addition to our participating members. A complete day of scientific programs has been arranged for Monday with the guest speakers participating in the General Session in the morning in the Clover Room. The first half of the Instruction Courses will be given Monday afternoon, and the second half of the Instruction Courses will be given Tuesday morning. The Instruction Courses are being given in many instances by the invited guest speakers as well as our own members. Many of the courses will have an interest for both eye and ear, nose and throat men this year.

*The Men's Luncheon will be held Monday noon in the Con*vention Hall of the Hotel Riveria.

The Social Events Committee has planned an interesting social program for the members and their wives during the time of the meeting. Two dinner show activities are planned Monday night at Hotel Sahara; the second dinner show will be the Annual Banquet held at the Hotel Riveria Wednesday night. Tuesday evening is to be free and a reservation desk to help members obtain other show reservations will be maintained at the Registration Desk. The golfers will use the Las Vegas Municipal Golf Course for their tournament. There is to be no fishing derby this year. An interesting sightseeing tour of Boulder Dam has been planned.

The President's Reception and Buffet Supper will be held Sunday evening, May 3, on the patio of the Hotel Riveria.

The Ladies Luncheon will be held on the patio of the Hotel Riveria, and will include an interesting fashion show.

It may not be possible to accommodate everyone in the Hotel Riveria due to the room limitation. Space in the Hotel Riveria will be assigned in order of the reservations received by the Hotel. When the space has been filled, reservations will be referred to the Hotel Sahara.

The Hotel Riveria is to be the headquarters of the meeting. Write directly to the Hotel Riveria for all room reservations.

DIRECTORY OF OTOLARYNGOLOGIC SOCIETIES

(Secretaries of the various societies are requested to keep this information up to date)

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Council Savoy Plaza, New York, N Y, January 10, 1959
Middle Park Plaza Hotel, St Louis, Mo, January 12-13, 1959
Western The Ahwahnee Hotel, Yosemite Valley, Calif, January 17 18, 1959
Southern Academy of Medicine, Hotel Atlanta Biltmore, Atlanta, Ga, January 23 24, 1959

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TISSUE-CULTURE STUDIES OF OSTEOBLASTIC ACTIVITY IN OSSICULAR FRACTURES

ROBERT D BURTON, M D ,
and
MERLE LAWRENCE, Ph D ,
Ann Arbor, Mich

Fracture of the stapedial crura is a complication seen rather frequently in present-day attempts at mobilization of the stapes When fracture occurs, the continuity of the ossicular chain is often disrupted, and should the otologic surgeon terminate the procedure no improvement in his patient's hearing could be expected, however, some techniques employ intentional fracture of a crus, or of the footplate, to reestablish mobility of the oval window[1-2] Also, currently, Rosen[3] advocates the creation, in the footplate, of a small hole made with a tiny metal hook, or "fenestrator," which tears through footplate bone and endosteum, allowing visible seepage of perilymph through the resulting opening Because these methods of otologic surgery actually fracture living bone, it is of importance to study the repair process in bone following such a fracture

For many years the impression existed that the stapes is composed of peculiar, immature bone,[4] of a type which does not heal if fractured, however, very few investigations of

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*From the Physiological Acoustics Laboratory Department of Otolaryngology and Institute of Industrial Health School of Medicine University of Michigan This investigation was supported in part by the Research and Development Division Office of The Surgeon General Department of the Army under Contract No DA-49-007-MD-634 and by funds for research in Human Resources University of Michigan

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the cellular structure and pattern of ossicular bone have been carried out to see whether the bone is so unusual Fundamentally there is the question of whether any cells possessing osteogenic potential are associated with the ossicular bone To understand the healing process of any bone one should take a "high power" view of it, focusing attention on the cell as the primary unit for study

The fact that ossicular fractures can and do heal by bony union has been proven by recent experimental studies Altmann and Basek state that new bone was formed in eight of 15 cases when small bone fragments of the stapedial footplate were depressed into the vestibule Bellucci and Wolff state that fracture of the stapes is usually followed by accretion of new bone regardless of site of fracture In five cases involving fracture of stapedial crura all showed varying degrees of deposition of new bone

Bone is often pictured as an inorganic, static structure composed of phosphate, calcium and carbonate salts This is actually the intercellular matrix which is maintained and changed by the cellular components of this bone Rather than a calcific conglomeration of salts it is a living, changing, metabolizing tissue composed of cells just as is all active body tissue It is the basic unit of bone, the living cell, with which this study is concerned, especially the response of the cell to injury of the bony matrix To make this possible tissue-culture techniques are employed

PROCEDURE

During the course of aseptic middle-ear operations on humans and guinea pigs the stapes was removed and placed in a vial containing sterile balanced-salt solution (Hank's) The pH of this solution was adjusted between 7 2 and 7 4 by balancing the CO_2 content This pH was determined through observation of the color change of phenol red which was added to serve as an indicator The balanced salt solution and the ossicles were then poured into a sterile petri dish and the bones either fractured intentionally or left intact for control purposes Each separate stapes was then placed in a Porter flask containing a clot formed of equal parts of chicken plasma and chicken embryo extract, which also contained the pH indicator By occasionally opening the flask to allow the carbon dioxide to escape the pH was maintained at its original value A few drops of horse-serum medium were placed on top of the clot and the specimen Generally this was changed at regular intervals so as to provide a continuous supply of nutrient material The flask was generally closed with a rubber stopper and incubated at a temperature of 38° Centigrade for various lengths of time Cellular growth was observed microscopically, and when the activity appeared to be slowing down, the bone and clot were fixed for histological processing

The fixative used was generally either a large quantity of 10 per cent neutral formol or Orth's fluid In preparing the specimens for histological study a small amount of potassium dichromate, as advised by Orth,[7] was used in the fixative This seems to harden the tissues more than plain formol, a procedure which enables the tissue to withstand the shrinking effects of higher alcohols and the heat of embedding during processing The bones were left for about 24 hours in this solution and then decalcified for six to twelve hours in 1 per cent nitric acid The tissues were then embedded in paraffin, sectioned at 10 microns, and after being mounted serially were stained with hematoxylin and eosin Two human and nine guinea pig stapedes were cultured and observed by this method

RESULTS

In fetal life the stapes begins as a cartilage "model" which subsequently becomes ossified This process according to Anson, Cauldwell and Bast,[8] is quite comparable to that found in a typical long bone of the body such as the tibia A major difference, as pointed out in their article, lies in the fact that the stapes is of adult size in about 20 weeks in the fetal organism, whereas the tibia requires about 20 years to reach adult proportions The similarity of the stapes to the long bones of the body goes even further both have layers of cells on their surfaces, which have osteogenic ability These cells are the so-called osteoblasts and play an important part in adding bony substance during the growth and development stage, and also serve as the primary unit during the healing of bone fractures

The stapedial crura are largely composed of periosteal bone which is covered by periosteal membrane and mucous membrane Beneath the periosteal membrane is a layer of osteogenic cells recessed in jagged crevasses of the underlying bone These are the cells that respond to injury when the associated bone is fractured A similar layer of osteogenic cells is present beneath the endosteal membrane of the footplate

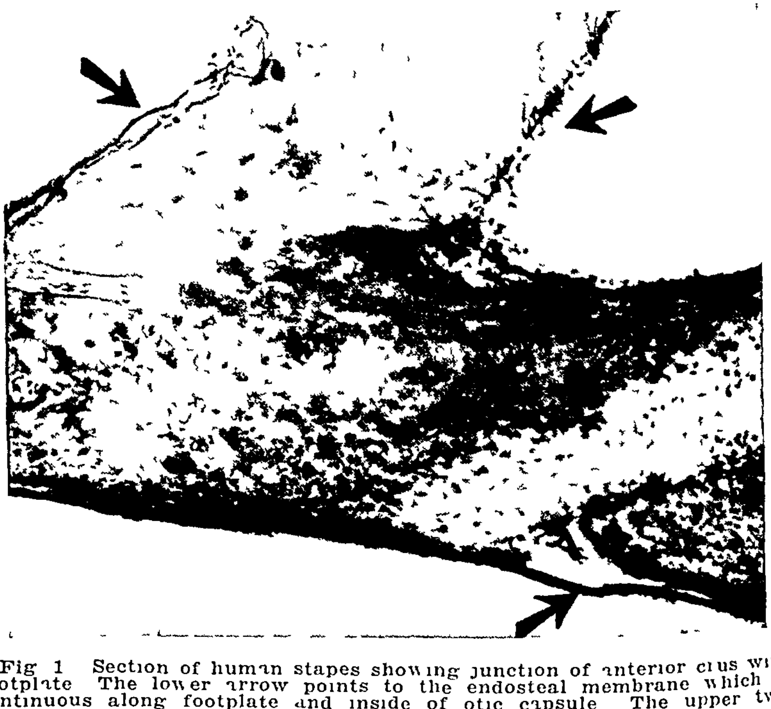

Fig 1 Section of human stapes showing junction of anterior crus with footplate The lower arrow points to the endosteal membrane which is continuous along footplate and inside of otic capsule The upper two arrows point to the periosteal membrane HTB 51R X200

Figure 1 is a photomicrograph of a sectioned normal human stapes showing these layers This picture illustrates the crural-footplate junction and the insertion of the footplate

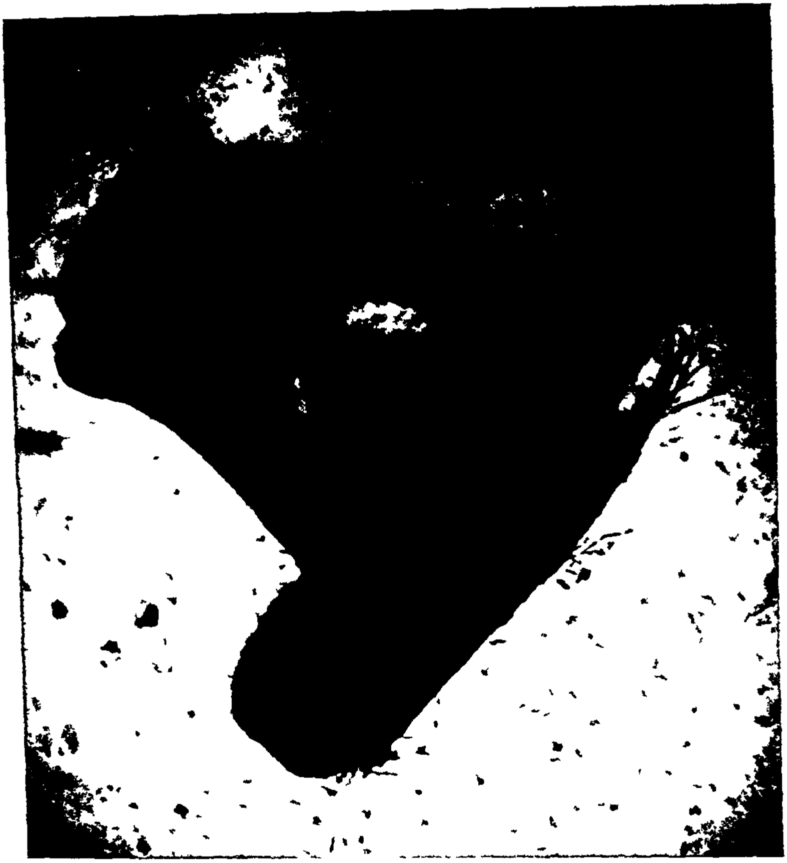

FIG 2 Guinea-pig stapes after eight days in tissue culture Fibroblasts can be seen growing out from site of fracture GP 174L.

into the oval window The periosteal bone of the crus is shown at the upper portion of the section, covered with periosteal membrane and cuboidal cells of the mucous membrane Beneath the footplate a heavy endosteal membrane is seen which shows complete continuity to the endosteal membrane of the otic capsule The osteogenic layer of cells lie tightly nestled in the recesses of both the periosteal and endosteal bone

When a fractured stapes is placed in the tissue-culture medium two morphologically different types of cells are produced Figure 2 is of a guinea-pig stapes which has had a

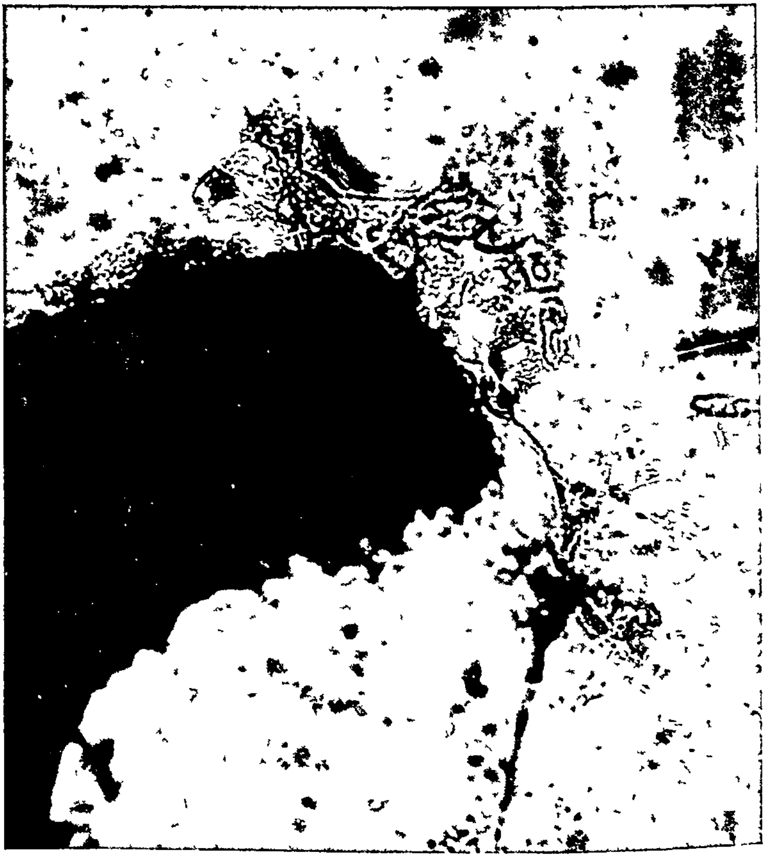

Fig 3 Another guinea-pig stapes after eight days in tissue culture Osteoblasts can be seen clustered around end of a fractured crus GP 178R

footplate fracture and then was cultured by placing it in a flask containing the chicken plasma-embryo extract clot The picture was taken on the eighth day of culture while the specimen was still alive and growing vigorously in the Porter flask Along the lower edge of the stapes long slender cells are proliferating and fanning out in a burst arrangement These cells have the morphologic appearance of fibroblasts and may be arising from torn endosteal membrane

A different type of cell is seen in Figure 3 This guinea-pig stapes was fractured and entirely separated from the footplate The picture was taken while the bone was living and

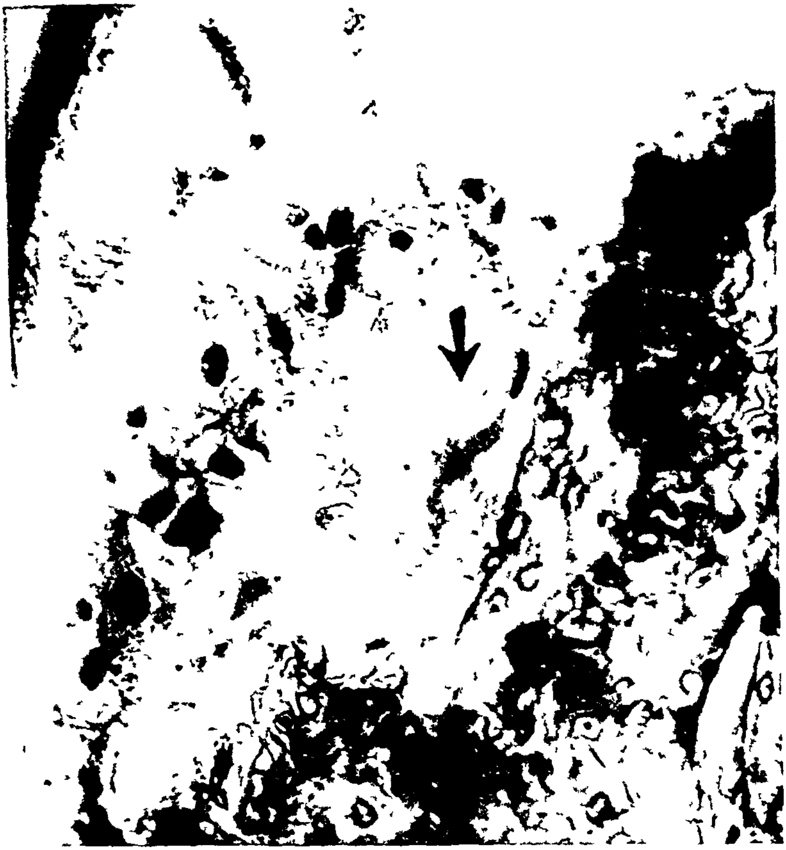

Fig 4 Histologic section through the fracture site of stapes shown in Fig 3 The arrow points to the osteoid tissue being laid down by the cluster of osteoblasts Note the osteoblast being transformed into an osteocyte by becoming embedded in the osteoid material GP 178R X380

after growing in tissue culture for eight days These are plump cells with prominent nuclei and are arranged in a semicircle around the fractured end of the crus The cells are much larger than those seen in Figure 2, and morphologically resemble osteoblasts

The problem arises as to the nature of the cells present in these two pictures One cannot label a cell as capable of producing a type of tissue until the cell actually has shown its ability to produce a special type of tissue Thus an osteoblast cannot be classified with absolute certainty until it has

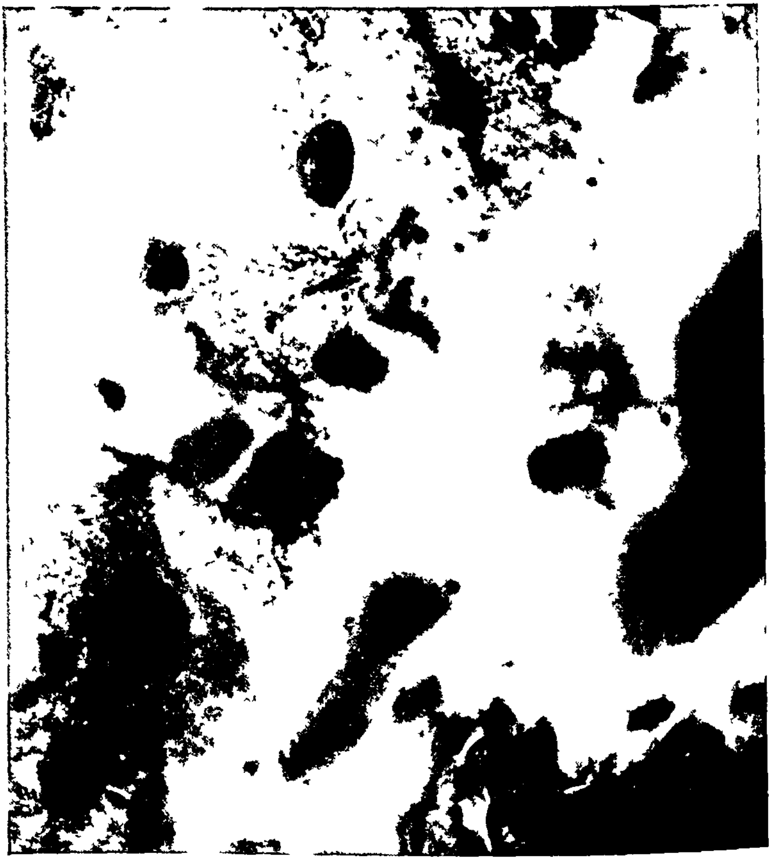

Fig 5 Oil immersion study of small portion of area shown in Fig 4 The typically prominent pair of nucleoli can be seen in the nuclei of several of the osteoblasts GP 178R X700

aided in the production of bone Likewise, a fibroblast cannot be definitely classified as such until it has aided in the production of fibrous tissue In most instances, however, we must rely on the morphological and histological characteristics of the cell in question in order to classify it It is well known that environmental factors such as pH, temperature change and the like alter these features and could result in mistaken identity if these variables were not carefully controlled

Figure 4 is a photomicrograph of a histologic section made through the crural fracture seen in the guinea-pig stapes of

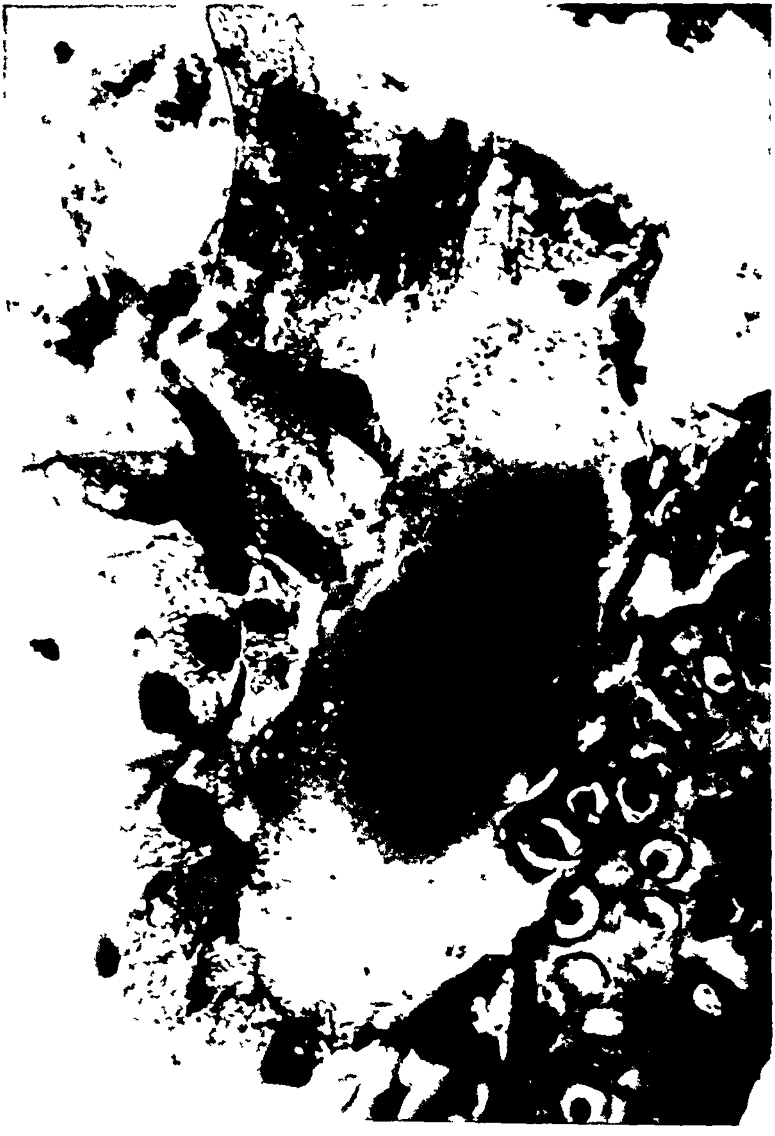

Fig 6 A section through a second fracture site near the neck of the stapes shown in the last three figures There is vigorous osteoblastic activity with the deposition of osteoid tissue GP 178R X620

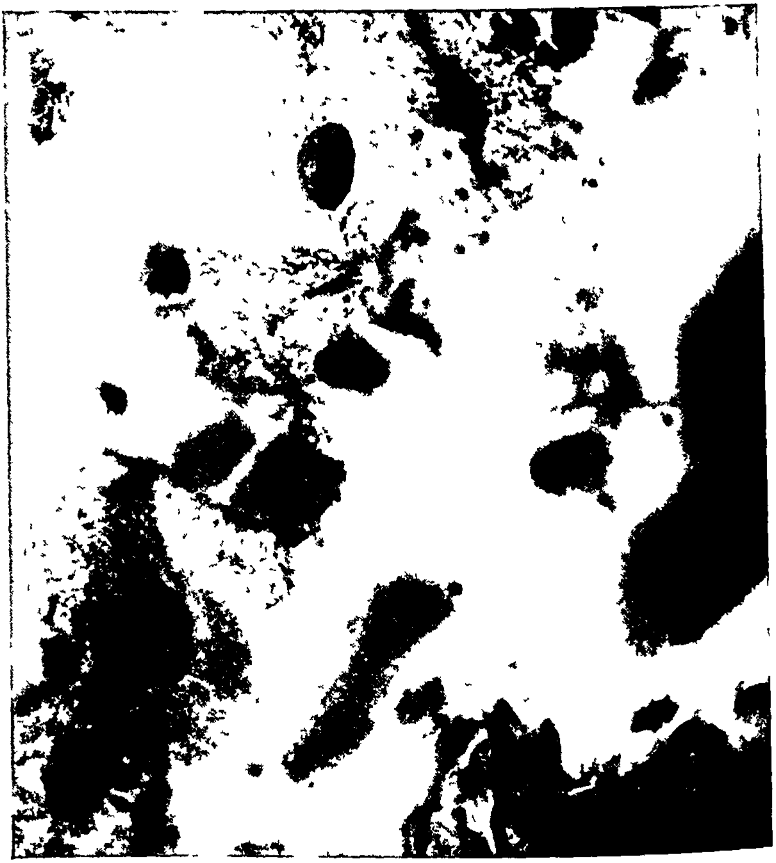

Fig 5 Oil immersion study of small portion of area shown in Fig 4 The typically prominent pair of nucleoli can be seen in the nuclei of several of the osteoblasts GP 178R X700

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Figure 4 is a photomicrograph of a histologic section made through the crural fracture seen in the guinea-pig stapes of bone is being formed some of the osteoblasts become embedded with this osteoid matrix and are then known as osteocytes [10] Their function there is to maintain and nourish the surrounding bony matrix Shown in Figures 4 and 5 is an osteoblast becoming enmeshed in this osteoid tissue, apparently beginning its transformation into an osteocyte

The bony tissue shown in the above figures was being formed by cells of the periosteal layer and thus is produced by intramembranous ossification This is the same manner in which new bone is added to the shaft of a mature long bone of the body Such intramembranous formation of bone was the only type observed in the repair of stapedial fractures in tissue-culture study

Histologically, guinea-pig stapedes appear practically identical to those of humans, however, when the human stapedes were fractured and placed in a tissue-culture medium the fracture site produced heavy growth of fibroblasts and osteoblasts but no evidence of osteoid tissue formation There are several factors which may account for this

Not all presumably living bone when removed from a living animal shows cellular outgrowth when placed in the culture medium, and the production of osteoid tissue is even rarer Only two of the nine guinea-pig bones showed this type of tissue formation, although extensive osteoblastic activity was seen in the others, and it may have been that the use of only two human stapedes was not a large enough sample Failure of the human material to produce osteoid tissue might also be attributed to the technique for obtaining and transporting the bone from operating room to laboratory This necessitated a longer time stay for the bits of bone in the balanced-salt solution at variable temperatures before being placed in the culture medium and incubator

It is also possible, of course, that human-stapedial bone does not react in tissue culture to the stimulus of a fracture, as does guinea-pig stapedial bone, however, the striking evidence of their close morphologic and histologic response in tissue-culture medium tends to support the impression that they are very similar to one another Both produced extensive

Figure 3 The upper two-thirds of the crus is depressed inward to a moderate degree and the jagged edge of bone is seen in the lower one-third portion of the crus This stapes was in tissue culture for eight days and showed vigorous growth from the beginning In the area of the depressed fracture a clump of osteoblasts have formed a semicircle, and are laying down a pink homogeneous material, presumably osteoid tissue These osteoblasts probably have originated from the jagged crevasses in the periosteal bone just beneath the periosteal membrane, and have been stimulated into action by the fractured bone These active osteoblasts resemble those decribed by Weidenreich [9] The nucleus is large and has one or two prominent nucleoli The cytoplasm stains with basic dyes and contains numerous threadlike mitochondria, and often one osteoblast is connected to its neighbor by thin cytoplasmic processes The prominent nucleoli are clearly seen in Figure 4

In Figure 5, which is a higher magnification of the area shown in the preceding figure, the cell structure is even more clearly seen The nucleoli are especially prominent in several of the osteoblasts

Figure 6 is a photomicrograph of a section made through another site of guinea-pig stapedial fracture This one was made at the junction of the crura with the neck of the stapes Mature cartilage can be seen at the lower right of the photomicrograph with dark, shrunken chondrocytes in the lucunae This stapes, after fracture, was placed in tissue-culture media where it remained for eight days Again we see, clustered around the site of injury, a number of active osteoblasts which were apparently engaged in laying down osteoid tissue Some of the nucleoli can be seen in the nucleus of several osteoblasts in this figure

The histological and morphological characteristics of these two distinct types of cells support our contention that the cells initially seen in the Porter flask in Figure 2 are fibroblasts, and those vigorously growing around a stump of a fractured crus in Figure 3 are osteoblasts The evidence that these latter cells are capable of laying down osteoid material aids in further identifying these cells as osteoblasts As new fracture, stimulates new bone formation with a gloomy prognosis for either keeping this "fenestra" open, or for preserving the fracture separation

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NEW RESEARCH LABORATORY

The Elbyrne G Gill Eye and Ear Foundation, 711 So Jefferson St, Roanoke, Va, announces the establishment of a Research Laboratory in conjunction with the Eye Bank and Sight Conservation Society of Virginia under the direction of Miss Jean Swartz, M S in chemistry The laboratory is prepared to make the dye test for Toxoplasmosis outgrowth of fibroblasts when the mucous and periosteal membranes were traumatized, and both showed evidence of osteogenic potential by production of osteoblasts at or near the site of fracture, therefore, it seems highly probable that the failure of the human material to produce osteoid tissue was due either to technique or chance, and that in the living organism healing should take place in most stapedial fractures whether the host organism is human or animal

COMMENT

Unquestionably an osteogenic layer of dormant osteoblasts does exist along the surface of ossicular bone These osteoblasts respond to a stimulus such as fracture and carry out a repair process similar to that found in bone elsewhere in the body Ossicular bone is a living, cellular tissue whose size, shape and nutrition depend on living cells, or osteocytes Although these studies were carried out by tissue-culture methods we have no reason to believe that these osteoblasts and fibroblasts should react differently in a living human organism Human cancellous bone frozen for several days has shown production of osteoid tissue when placed in tissue culture by Ray and co-workers[11], therefore, there is no reason to suppose that fracture of the crura or footplate would remain in a state of non-union Any fracture that is made will have a tendency to heal resulting in return of the patient's hearing to the pre-operative level, also, the extensive production of fibroblasts indicates that fibrosis can result from middle-ear manipulations

SUMMARY

Through the method of placing fractured stapes in tissue-culture media and observing the cellular activity both grossly while the tissue is living, and microscopically after histologic processing, it has been demonstrated that

1 Injury to the periosteal membrane results in fibroblastic proliferation,

2 Tearing of the osteogenic layers, together with bone fracture such as occurs in footplate fenestration or crural perience of working in close collaboration with my colleague, Dr M Lederman, of the Royal Marsden Hospital, an institute which specializes in the treatment of malignant disease, and which is well equipped with modern radiotherapeutic apparatus

Recent advances in the technique of radiotherapy and of surgery have been considerable I am not competent to deal with the former, but have acquired some experience in the newer operative methods Better and safer anesthesia, and greater use of blood transfusion and of antibiotics have allowed the performance of major *en bloc* resections without undue risks and without an unduly high operative mortality

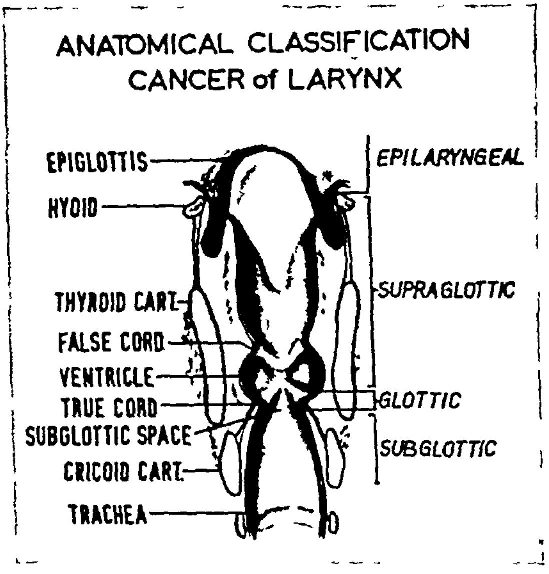

Fig 1 Anatomical classification of cancer of the larynx An imaginary line through the hyoid bone divides the epiglottis into two Tumors arising above this line are classified with laryngo-pharyngeal carcinomata

Surgical excision has thus been extended to include widespread neoplasms formerly considered to be inoperable On the other hand, the trend has been to treat by radiotherapy alone early localized lesions, with surgery reserved for the failures There has thus been a reversal of the treatment

MANAGEMENT OF CARCINOMA OF THE LARYNX AND LARYNGO-PHARYNX*

Recent Experiences

F BOYES KORKIS, F R C S (Ed) F R C S (Eng) F I C S
(By Invitation),

London, England

The treatment of malignant disease of the larynx and of the laryngo-pharynx is a controversial matter of world-wide interest In the past, the rival and often conflicting claims of surgical excision and of radiotherapy have been hotly debated without reaching any definite conclusions, but in Britain a measure of agreement is gradually emerging

This has been brought about by a better knowledge of what can, and what cannot, be achieved by these differing forms of therapy Closer cooperation between surgeon and radiotherapist has done a great deal to bring about this understanding Combined clinics have been established in which every patient is seen by an experienced expert in each field, thus, a patient attending a joint consultation clinic is assured of a carefully considered opinion as to the method of treatment most likely to be of benefit Each new case is an individual problem, and treatment is advised in the light of the anatomical situation and extent of the lesion, the pathology, the facilities available for treatment and the particular circumstances and wishes of each patient The results of treatment are followed up regularly by both members of the team, and secondary treatment for recurrence is instituted with a greater degree of certainty at the earliest possible moment Such a clinic was established at the Metropolitan Ear, Nose and Throat Hospital, and I have had the opportunity and ex-

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*Read by invitation at the Meeting of the Eastern Section of the American Laryngological Rhinological and Otological Society New York N Y Jan 8, 1959

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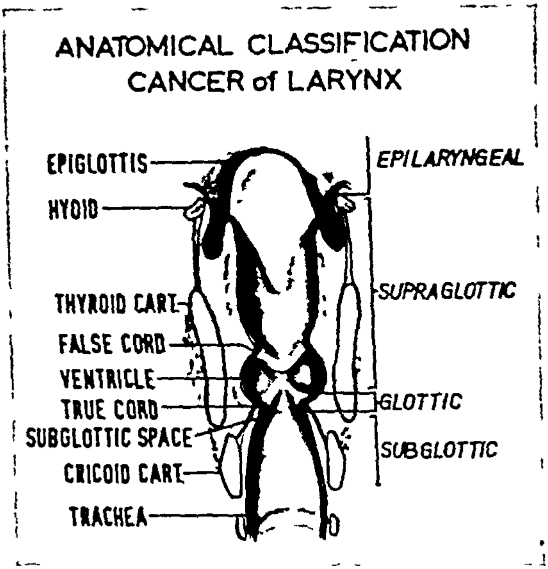

Fig. 1. Anatomical classification of cancer of the larynx. An imaginary line through the hyoid bone divides the epiglottis into two. Tumors arising above this line are classified with laryngo-pharyngeal carcinomata.

newer operative methods. Better and safer anesthesia, and greater use of blood transfusion and of antibiotics have allowed the performance of major *en bloc* resections without undue risks and without an unduly high operative mortality.

Surgical excision has thus been extended to include widespread neoplasms formerly considered to be inoperable. On the other hand, the trend has been to treat by radiotherapy alone early localized lesions, with surgery reserved for the failures. There has thus been a reversal of the treatment plan, which was formerly adopted, whereby early tumors were removed and advanced neoplasms were given radiotherapy In consequence, the radiotherapist is having the first chance of treating the early cases which are more likely to be curable, a most important fact which must be borne in mind constantly when comparing the results of therapy

A system of classification into anatomical types, clinical stages and histological groupings is vitally necessary to make for a terminology common to radiotherapists and to laryngologists, in order to compare like cases with like in any statistical review In the past, comparisons between the two forms of treatment have been misleading and unscientific, as widely differing criteria have been adopted in the publication of results

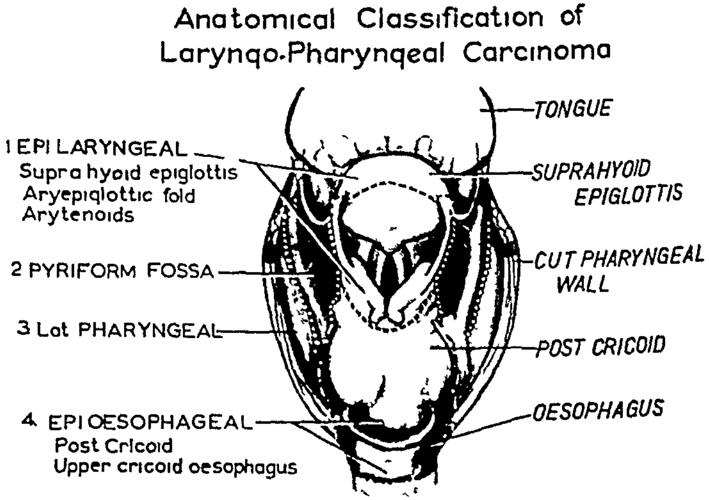

Fig 2 Anatomical classification of laryngo-pharyngeal cancer Tumors arising from the anterior surface of the epiglottis the valleculae and the posterior part of the tongue are excluded—they are glosso-epiglottic eoplasms

It is, therefore, opportune to take stock of the present position against this background

PERSONAL MATERIAL

Individual British otolaryngologists are unable to collect as large a series of cases as their American colleagues. In Britain, the otolaryngologist usually remains more general in his outlook, and there is little ultra-specialization within the province of ear, nose and throat work, thus, the available material is distributed among a larger number of specialists. This fact, coupled with the invasion of the general surgeon into our field, reduces the numbers seen by British specialists as compared with American laryngologists who tend to concentrate their endeavors on a particular disease within the specialty. This introduction is necessary to explain the small number of personal cases of carcinoma of the larynx and of the laryngo-pharynx which form the basis of this report—one concerned with individual experience.

TABLE I

ANATOMICAL DISTRIBUTION—108 CASES

	Male	Female	All
Cancer of Larynx (64 Cases)—			
Supraglottic	6	1	7
Glottic	40	3	43
Subglottic	12	2	14
Cancer of Laryngo Pharynx (44 Cases)—			
Epilaryngeal	10	0	10
Sinus Pyriformis	7	1	8
Epiesophageal	6	20	26
Total (108 Cases)	81	27	108

This paper deals with a series of 108 cases (see Table I), which have been under my own care in the last nine years. This approach has been deliberately chosen in preference to one relating to a large number which have been culled from case-notes borrowed from many sources and concerning patients who have been treated by several surgeons in the same hospital. It allows a considered presentation of personal opinions gained solely by *first hand* experience in the management of this disease. The time limitation is also deliberate. Earlier cases have been excluded for several reasons.

1 Relative inexperience at first

plan, which was formerly adopted, whereby early tumors were removed and advanced neoplasms were given radiotherapy In consequence, the radiotherapist is having the first chance of treating the early cases which are more likely to be curable, a most important fact which must be borne in mind constantly when comparing the results of therapy

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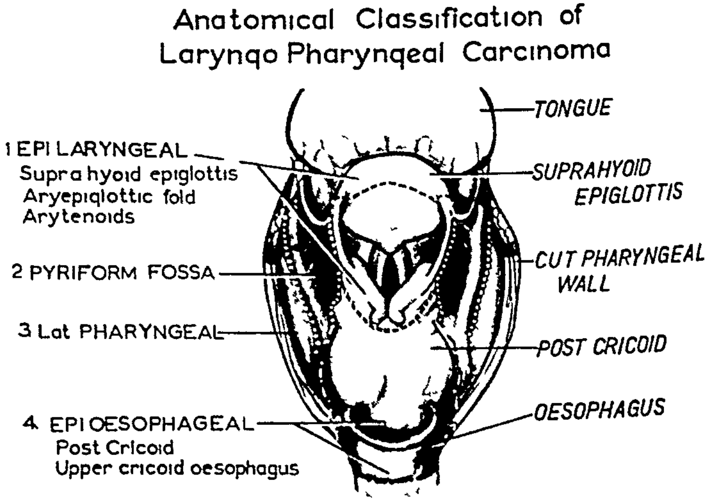

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2 Glottic Tumors arising from upper surface and edge of true vocal cord, anterior and posterior commissures

3 Subglottic Tumors arising from inferior surface of cord, subglottic space

B *Cancer of the Laryngo-Pharynx* is divided into [2]

1 Epilaryngeal Tumors arising from supra-hyoid epiglottis, aryepiglottic fold and arytenoid

2 Sinus pyriformis

3 Epiesophageal — Cricopharyngeal, pharyngo-esophageal, cervical esophagus

4 Posterior and lateral pharyngeal walls [2]

The distribution of cases in this series according to site and sex is shown in Table I

2 *Clinical Staging*

The prognosis is related to the extent of invasion which is present when treatment is undertaken The system of clinical grading followed at the Metropolitan Ear, Nose and Throat Hospital is as follows (Lederman, M [1,2])

A *Laryngeal Cancer* Stage

1 The tumor is limited to the tissue of origin and the larynx is freely mobile,

2 Laryngeal mobility is impaired or extension has occurred beyond the tissues of origin but still remains within the confines of the larynx

3 The affected part of larynx is fixed or extra-laryngeal spread is present to thyroid cartilage, pre-epiglottic space, trachea, laryngo-pharynx or to a single mobile homolateral lymph node

4 Contra-lateral, bilateral or fixed lymph nodes, simultaneous or consecutive primary or distant metastases are present

B *Laryngo-pharyngeal Cancer* Stage

1 Limited to tissue of origin

2 Deficiencies in case-taking, record-taking and follow-up, making classification and an accurate report impossible

3 The remarkable improvement in selection of cases for treatment in the last decade

4 The recent advances in radiotherapeutic and surgical techniques which bring into focus one's own changing views by concentrating on current methods of therapy

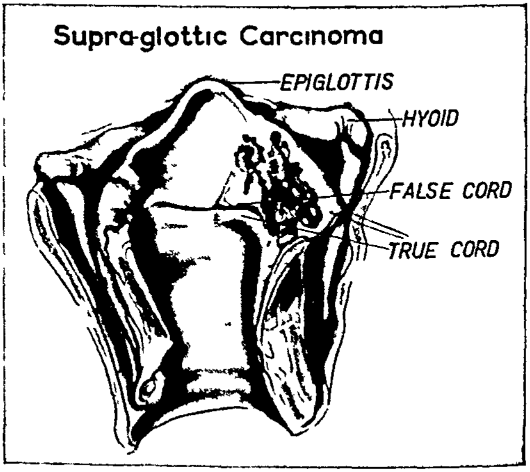

Fig 3 Supraglottic type of cancer of the larynx Artist's impression of a laryngectomy specimen the tumor arising from the infra-hyoid epiglottis and false cord

CLASSIFICATION OF CASES

1 *Anatomical Site*

For many years carcinoma of the larynx was divided clinically into an intrinsic and an extrinsic group In view of the vastly different prognosis in these two types, such a broad distinction is inadequate An anatomical classification according to a more exact site of origin, as suggested by Lederman[1 2] (1952-1954), has been adopted

A Cancer of the Larynx is divided into

1 Supraglottic Tumors arising from Infra-Hyoid Epiglottis, False Cord, Ventricle

In this analysis, cases of *in situ* carcinoma and of borderline malignant lesions are excluded Herein lies one of the main sources of error in histological interpretation What one pathologist reports as negative, another will regard as probably malignant Their inclusion helps to improve the statistical cure-rate, but confuses the real issue, the true prognosis For who is to say how many of these are false positives? An unduly optimistic picture of the disease emerges when such questionable lesions are included with frankly malignant tumors

The bad prognosis associated with immature, anaplastic lesions is well known It is, therefore, most important to recognize this group as a separate entity They numbered eight in this series, seven of these occurring in the glottic and subglottic regions

TABLE III

HISTOLOGICAL GROUPING 108 CASES

	Frank Squamous Carcinoma Primary or Recurrent	Anaplastic Carcinoma
Supraglottic	7	0
Glottic	39	4
Subglottic	11	3
Epilaryngeal	9	1
Sinus Pyriformis	8	0
Epiesophageal	26	0
	100	8

BIOPSY.

Direct laryngoscopy and biopsy give a certainty of diagnosis that can be obtained in no other way This essential investigation is never delegated to an assistant, but is personally performed The exact position and probable extent of the growth is ascertained, and a piece is removed from the most likely portion of the tumor The percentage of false negative reports is thereby reduced, but absolute reliance is not placed on negative biopsy findings alone Two false negative biopsies were returned in one of my cases, but despite this, laryngectomy was performed on clinical grounds The clinical diag-

2 Local spread but still within the confines of the pharynx or of the cervical esophagus

3 Spread outside walls of pharynx or cervical esophagus

4 Contra-lateral, bilateral or fixed lymph nodes, distant metastases or simultaneous or consecutive primary cancer

Table II shows the number of patients and distribution according to site and stage

TABLE II

DISTRIBUTION OF CASES ACCORDING TO SITE AND STAGE

	Stage 1	Stage 2	Stage 3	Stage 4
Supraglottic (7 Cases)	0	2	4	1
Glottic (43 Cases)	14	11	17	1
Subglottic (14 Cases)	1	1	11	1
Epilaryngeal (10 Cases)	0	1	7	2
Sinus Pyriformis (8 Cases)	0	0	3	5
Epiesophageal (26 Cases)	0	2	16	8
Total (108 Cases)	15	17	58	18

3 *Histological Grouping*

The allocation of a particular biopsy specimen to one of the four histological groups suggested by Broders[3] (1926), is misleading and has been discontinued The small portion submitted for biopsy may be unrepresentative of the tumor as a whole, and pathologists differ in their groupings of the intermediate varieties, *i e*, those between the well differentiated and the anaplastic types (Colledge)[4]

Precise division into well differentiated, intermediate and anaplastic groups is possible only when the whole tumor is available for examination Surgically excised neoplasms can be divided into these three groups, but when assessing the grouping on a small biopsy specimen, inaccuracy is avoided by taking a broader classification into frank squamous carcinoma, anaplastic carcinoma and recurrent squamous carcinoma The histological classification in this series, according to this basic grouping, is shown in Table III

Supra-Glottic Lesions Primary treatment by radiotherapy followed by laryngectomy has given the best results (see Table IV) Metastases to glands occur infrequently and do not warrant "white" *en bloc* neck dissection, but when nodes are manifest this operation is performed in preference to radiotherapy, either contemporaneously with laryngectomy or later, when clinical involvement occurs postoperatively

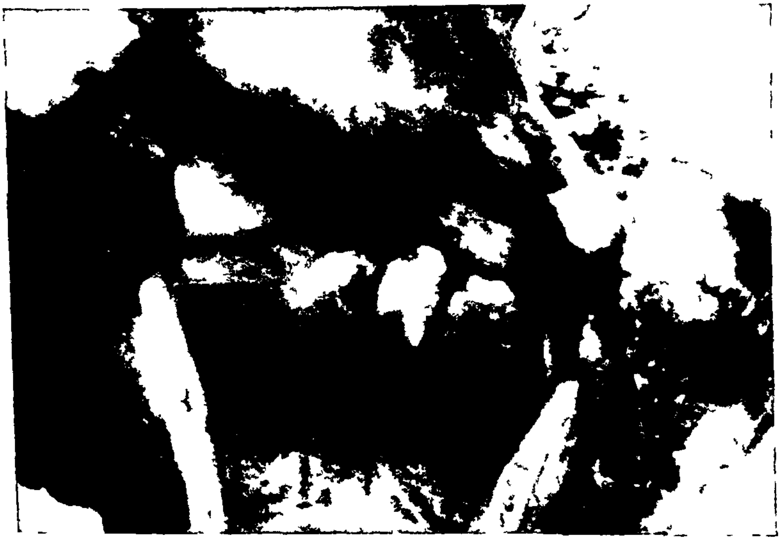

Fig 4 Glottic type of cancer of the larynx A laryngectomy specimen photographed to show massive growth involving the whole length of the right true cord as seen from behind The section of tumor removed post-operatively for thorough histological study is well demonstrated at the mid-point of the cancer

Glottic Disease This is the most frequent type of lesion, but the total number of cases in this series is too small to make a worthwhile and accurate analysis of the percentage of five-year cures attained by surgery, by radiotherapy or by their combination Instead, a detailed analysis of the outcome of treatment of each case is studied This searching inquisition is used with the object of discovering the treatment most likely to achieve success in the future

At the outset, Stage 1 and Stage 2 cancers were usually treated by laryngo-fissure or by laryngectomy, respectively, nosis was confirmed subsequently by a positive report when the whole specimen was searched histologically This error on biopsy is especially liable to occur with subglottic growths

TREATMENT AND RESULTS

Part I Cancer of the Larynx

Treatment has been related to the site, stage and to a lesser degree to the type of cell comprising the tumor

In general, anaplastic neoplasms in all areas are not subjected to primary surgery unless the lesions are early and well

TABLE IV

TREATMENT AND RESULTS—SUPRAGLOTTIC LESIONS

Case No	Sex	Age	Clinical Stage	Treatment	Result
1	F	62	4	T-R only	Died with disease in 3/12
2	M	62	3	T-R LY	Alive Free of disease in 40/12
3	M	59	2	T R LY	Alive Free of disease in 22/12
4	M	74	2	T R LY	Alive Free of disease in 16/12
5	M	73	3	T C	Alive with disease in 12/12
6	M	55	3	LY D X R Post op	Died with disease in 9/12
7	M	69	3	D X R only	Died with disease in 5/12

Abbreviations T-R—Teleradium LY—Laryngectomy T-C—Telecobalt D X R —Deep X-ray Therapy –/12 Time in months

localized Laryngofissure is unsuccessful in Stage 1 anaplastic cases and mutilating radical operations alone have less chance of controlling the disease Primary radiotherapy is given in such cases, and surgery is reserved for recurrence An *en bloc* dissection is advisable in conjunction with radical surgery whenever there is a likelihood of clinical involvement of glands, as secondary neck dissection has less chance of affecting a cure

In non-anaplastic squamous carcinomata, treatment is selected according to the clinical stage and site of the neoplasm, and various combinations of therapy have been tried It is now usual to treat early glottic disease by radiotherapy, reserving surgery for advanced cases, uncontrolled primary lesions, recurrence after radiotherapy, and for cervical glandular metastases would not be treated by laryngo-fissure Luckily, both of these patients are free from disease nine years after laryngectomy One patient developed a squamous cell carcinoma on the remaining cord six years after laryngo-fissure, and this is probably a second primary rather than a recurrence, as no carcinoma was found on the operated side Two of the other patients had leukoplakia of larynx and subsequently developed

TABLE VI

GLOTTIC CARCINOMA—ANALYSIS OF 19 PRIMARY RADIOTHERAPY CASES

No	Sex	Age	Clinical Stage	Histology	Form of R-Thy	Sec Treat Recur	Fate
1	M	54	2	Sq	T R	—	A>5 years
2	M	33	1	Sq	T R	—	A>5 years
3		58	1	Sq	T-R	—	A>4 years
4	M	62	2	Sq	T R	—	A>4 years
5	M	70	2	Sq	T R	—	A>3 years
6	M	53	3	Sq	D X R T C	LY for Perichondritis	D (Post op)
7	F	74	3	Sq	T-R	—	D 3/12
8	M	76	2	Sq	T-R	—	A>2 years
9	M	72	3	Sq	T-R	LY	A>4 years
10	M	51	3	Sq	T-R	—	A>2 years
11	M	61	1	Sq	T-R	—	R>2 years (2ndries Ribs)
12	M	69	2	Sq	T R	—	D 10/12
13	M	64	3	An	T-R	LY, 2y Block, H V T	D 6/12
14	M	49	3	Sq	T R	LY	D 14/12
15	M	62	2	Sq	T-C	—	A 12/12
16	M	69	3	Sq	T-R	LY	D 15/12
17	M	71	3	An	T R	LY	A>4 years
18	F	67	3	Sq	T-R	—	A 18/12
19	M	46	3	Sq	H V T	LY	D 11/12

Key F—Female M—Male Sq—Squamous An—Anaplastic T-R—Teleradium T-C—Telecobalt H V T—High Voltage Therapy LY—Laryngectomy A—Symptom free R—Alive with disease D—Died of disease >—Longer than

recurrent carcinoma on the opposite side Today such cases would not be treated by laryngo-fissure, in view of the premalignant nature and the likelihood of multicentric malignant degeneration The remaining two patients were found to have histological evidence of malignant disease on the opposite cord, although there was no clinical evidence of this at the time of the laryngo-fissure A routine biopsy is always taken from the junction of the anterior and middle thirds of the but in view of the success obtained with teleradium and telecobalt therapy, with preservation of full laryngeal function, primary surgery was largely abandoned in favor of radiotherapy With Stage 3 disease the number of cases requiring secondary laryngectomy was high, especially when there was unilateral involvement of glands, then, primary laryngectomy, combined with *en bloc* dissection, was the usual method of treatment

Table V shows the primary treatment adopted in the 43 cases falling within the glottic group and Tables VI, VII, VIII, IX show their fate

TABLE V

PRIMARY TREATMENT IN 43 GLOTTIC CASES

Clinical Stage	Radiotherapy (19 Cases)	Laryngofissure (14 Cases)	Laryngectomy (9 Cases)	Palliative (1 Case)
1	3	14	0	0
2	6	0	2	0
3	10	0	7	0
4	0	0	0	1

Primary Radiotherapy

Of the 19 primarily irradiated cases, seven required laryngectomy for recurrence, all of these being clinical Stage 3, and of these seven, five died of the disease Stage 1 and 2 disease does well with radiotherapy, but laryngectomy is often necessary for more advanced lesions

Primary Thyrotomy

The primary laryngo-fissure (thyrotomy) cases (all Stage 1) are analyzed in Table VII From this it will be seen that seven are free of disease, but seven required secondary laryngectomy All the laryngectomized patients have done well, six being alive and free from disease for periods ranging from nine years to six months, while the seventh patient died from intercurrent illness but free from malignant disease (proved by postmortem) three-and-a-half years after laryngectomy

Two of the seven were of anaplastic histology, and today from recurrence at postmortem, and the remaining four have remained free from disease for periods between eight years and over two years A comparison of the end-results of the two primary methods in Stage 3 disease shows that four out of ten primarily irradiated patients are symptom free, but three of these survivors required secondary laryngectomy, whereas four out of seven of those treated by primary surgery remained symptom free, however, five out of seven patients (Stages 2 and 3) primarily irradiated and secondarily laryngectomized died of the disease (see Table IX)

TABLE VIII

GLOTTIC CARCINOMA—ANALYSIS OF 9 PRIMARY LARYNGECTOMY CASES

No	Sex	Age	Clinical Stage	Histol	Prim Treat	Result Prim Treat	Sec Treat	Final Result
1	M	56	3	Sq	LY	Glands in 2/12	Block Diss 2/12	D 18/12
2	M	35	3	Sq	LY	A 8 years	—	—
3	M	73	2	Sq	LY	I D 42/12	—	—
4	M	68	3	Sq	LY + Prim Block	Recur Esoph 4 years	Resection Esoph + Block, Contra Lat	R 56/12
5	M	69	3	Sq	LY	I D 2/12	—	P M No Ca
6	M	58	3	Sq	LY	A>2 years	—	—
7	M	70	2	Sq	LY	A>2 years	—	—
8	M	72	3	Sq	LY	A>7 years	—	—
9	M	67	3	Sq	LY	Recur glands 2 years	Block Diss 2 years	D 4 years

In the light of my present experience, radiotherapy, therefore, seems to be the primary treatment of choice for clinical Stages 1 and 2, with secondary laryngectomy reserved for uncontrolled disease, recurrence or anaplastic tumors With clinical Stage 3 disease, primary laryngectomy offers the patient the best chance of cure, but anaplastic cases are irradiated first, and neck dissection is subsequently combined with secondary laryngectomy This present analysis bears out my clinical impressions previously expressed elsewhere,[5] and the opinions of other authors McCall and Fisher[6] (1952), Schall[7] (1951), Gissillson and Lindgren[8] (1952), Lindsay and Ironside[9] (1955), etc apparently healthy cord, or from any other suspicious area These two cases substantiate the wisdom of this, as both patients were submitted to laryngectomy within a short period of the primary operation and have remained free of disease Thus, cancerous tissue is widely excised at the earliest possible moment by performing an adequate operation

Incidentally, the thyroid ala on the affected side is also removed and examined histologically Invasion was not found in these cases, but had this occurred, an early secondary laryngectomy would have been performed Histological studies such as these do sometimes prove the preoperative clinical staging to be incorrect

TABLE VII

GLOTTIC CARCINOMA —ANALYSIS OF 14 LARYNGOFISSURE CASES—ALL CLINICAL STAGE 1

No	Sex	Age	Histology	Result of Fissure	Sec Treat	Final Result after LY
1	M	66	Sq	Recurrence 6 years (? 2nd Primary)	LY	A>3 years
2	M	65	An	Recurrence	LY	A 9 years
3	M	43	An	Recurrence	LY and 1' Block	A 9 years
4	M	74	Sq	Recurrence	LY	I D 32/12
5	M	60	Sq	Recurrence	LY	A>5 years
6	M	64	Sq	+ Biopsy opp cord	LY	A 2½ years
7	M	62	Sq	A 5 years	—	—
8	M	78	Sq	A 18/12	—	—
9	M	60	Sq	A 8 years	—	—
10	M	62	Sq	A 5 years	—	—
11	M	57	Sq	A 7 years	—	—
12	M	65	Sq	+ or biopsy opp cord	LY	A 6/12
13	M	65	Sq	A 5 years	—	—
14	M	62	Sq	A 4 years	—	—

Key as before Added I D —died intercurrent disease free from malignancy

Primary Laryngectomy

Table VIII summarizes the nine primary lar gnectomy cases individually

Three developed recurrence, of the remaining six, two patients died of intercurrent disease but proved to be free reached the five-year period, two are dead, and one is alive with uncontrolled malignancy

Only one patient had clinically involved glands (bilateral) before treatment was started, necessitating a bilateral monoblock resection of gland fields and larynx, he has remained well for 17 months Prophylactic neck dissection is not performed routinely in this group because of the relatively low incidence of involvement of the cervical nodes (13 per cent, according to Lederman[13]).

TABLE X.
SUBGLOTTIC CARCINOMA—ANALYSIS OF 14 CASES

No	Sex	Age	Clinical Stage	Histol	Prim Treat.	Secy Treat	Result
1	F	39	1	An	T-R	Nil	A 5 years
2	M	76	2	Sq	T-R	H V T	R 3½ years
3	M	58	3	Sq	LY	—	A 8 years
4	M	71	3	Sq	LY	—	A 5 years
5	M	53	3	Sq	LY	H V T	D 5/12
6	M	63	3	An	LY	—	D 1 year
7	M	56	3	Sq	T-R	LY	D 3/12
8	M	64	3	Sq	H V T	LY	I D 14/12
9	M	59	3	Sq	T-R	LY	A 1 year
10	M	48	3	An	T-R	LY	D 7/12
11	M	62	3	Sq	LY	—	A 14/12
12	M	71	3	Sq	LY	—	A 2 years
13	F	59	3	Sq	Hemi-LY + T-R	H V T	R 14/12
14	M	52	4	Sq	LY — Bilat Block	—	A 17/12

In the future, it is intended to use radiotherapy as a preliminary to surgery in anaplastic disease, and to employ it as the first choice of treatment for the rare, early Stage 1 cases All others will continue to be treated by primary laryngectomy, with a combined monoblock neck dissection when the glands are clinically involved

Part II Cancer of the Laryngo-Pharynx

The poor prognosis associated with surgical treatment of this group of cancers in the past led to the custom of treating them by radiotherapy Disappointed with the results of radiotherapy, laryngologists are again veering towards surgery now that very radical excision is possible This is a world-

Subglottic Lesions The treatment of choice for subglottic carcinoma is regarded as surgical by most laryngologists, laryngectomy and block dissection giving the best results (Orton,[10] 1951, Ogura,[11] 1955, Work,[12] 1952)

Radiotherapists have achieved some successes, however, especially when the lesion is early (Lederman,[1] 1952) In this series, six out of 14 cases were treated by primary radiotherapy (see Table X) From this it will be seen that of those six, four were subjected to secondary laryngectomy The operation was offered to the other two, but was declined, and it is interesting to note that the only Stage 1 patient who had anaplastic disease, and who was treated solely by irradiation, has remained free of disease for over five years and has normal vocal function The two other patients with anaplastic histology have died of recurrence Only one of these received preliminary radiotherapy, and looking back it would have been advisable to have given this treatment prior to surgery in the other Postoperative radiotherapy will not cure the disease if surgery fails, but is used to palliate the condition

TABLE IX

GLOTTIC CARCINOMA—RECURRENT OR UNCONTROLLED—SECONDARY LARYNGECTOMY CASES (14)

No	Prim Treat	Prim Clin Stage	Subsequent Stage After Recurrence	Original Histol Group	Result=Time After Ly
1	L-F	1	2	Sq	A 3 years
2	L-F	1	3	An	A 9 years
3	L F	1	3	An	A 9 years
4	L-F	1	2	Sq	I D 32/12
5	L-F	1	3	Sq	A 5 years
6	L-F	1	2	Sq	A 2½ years
7	L-F	1	2	Sq	A<1 year
8	T R	3	3	Sq	A 4 years
9	T R	2	3	Sq	D 15/12
10	H V T	3	3	Sq	D 11/12
11	T R	3	3	An	A 4 years
12	T R	3	3	An	D 6/12
13	T R	3	3	Sq	D 14/12
14	T R	3	3	Sq	D 15/12

Of the eight cases treated by primary laryngectomy, five are alive and free of disease, but only two of these have myelitis of the mandible recently In this small number of cases this treatment plan appears to give the best results, as there are no survivors treated by primary radiotherapy

Sinus Pyriformis Lesions In view of the poor prognosis, seven patients in this group were treated primarily by radiotherapy and one was palliated, only one was subjected to secondary regional surgery, which proved unsuccessful (see Table XII)

TABLE XII
SINUS PYRIFORMIS CARCINOMA (8 CASES)

No	Sex	Age	Clinical Stage	Histol	Prim Treat	Result Prim Treat	Sec Treat	Final Result
1	M	59	4	Sq	H V T	Uncontrolled	—	D 11/12
2	M	75	3	Sq	T-R	Controlled		I D 3 yrs 9/12
3	M	61	3	Sq	T R	Uncontrolled		D 1 year
4	M	45	4	Sq	H V T	Uncontrolled	—	D 10/12
5	M	74	4	Sq	T-R	Uncontrolled	Reg Excision + Post op T-R	D 9/12
6	F	72	3	Sq	(T-C Incomplete)	Uncontrolled	—	D 14 days
7	M	51	4	Sq	T-C	Uncontrolled	—	R 7/12
8	M	63	4	Sq	Nil	Palliated	—	D 2/12

The great majority of the pyriform sinus neoplasms are very advanced before treatment is begun Perhaps the British cases are seen much later than those in the U S A, a fact which would account for the wide differences in the percentage cure rates reported by British and American authors The reported results obtained by adequate surgical removal are superior to those achieved by radiation, and in suitable early cases regional surgery is advisable To date, all cases seen by me have been too advanced to warrant primary surgical intervention Irradiation has only been of palliative help, and in no instance has it controlled the malignancy in the seven cases so treated

Epiesophageal Lesions These 26 patients also present a sorry picture, for no patient has survived longer than 13 months, irrespective of the type of treatment adopted (see Table XIII) Many cases were very advanced when first seen, wide trend, and it is opportune to inquire whether our present day results justify extensive and mutilating operations It is no wonder that some patients decline operation when the position is fully explained to them, but it is only right that this should be done, thus, the treatment is guided, to some extent, by the patient's own wishes When surgery is undertaken, excision implies a wide-field, monoblock removal of the tumor and of the lymphatic channels and gland fields on one or both sides, because of the likelihood of manifest or occult lymphatic spread Regional surgery, rather than local excision is, therefore, indicated

TABLE XI

EPILARYNGEAL CARCINOMA (10 CASES)

No	Sex	Age	Clinical Stage	Histol	Prim Treat	Result Prim Treat	Sec Treat	Result
1	M	53	3	Sq	Reg Excision	No recurrence	H V T	A>6 years
2	M	54	3	Sq	Reg Excision	Osteomyelitis mandible 5 years later	H V T	A>5 years
3	M	63	3	Sq	T-R	Uncontrolled 1°	Reg Excision	D 23/12
4	M	64	3	An	H V T	Uncontrolled 1°	Reg Excision	D 16/12
5	M	57	3	Sq	H V T	Uncontrolled 1°	Refused Op	D 3/12
6	M	82	2	Sq	Pall H V T (Incomplete)	Died during H V T	—	D 10 days
7	M	36	4	Sq	H V T	Uncontrolled 1° + 2°	—	D 4/12
8	M	55	2	Sq	Reg Excision	Local Recurrence	—	D 10/12
9	M	60	3	Sq	Reg Excision	Pulmonary Metastases	—	D 10/12
10	M	64	2	Sq	H V T (Incomplete)	Died during H V T	—	D 15 days

Epilaryngeal Lesions There are ten epilaryngeal cancers which are individually analyzed in Table XI The poor results obtained by various combinations of regional surgery and radiotherapy are disappointing There are only two survivors free of disease after a period of over five years, treated by regional surgery and postoperative irradiation, one of these survived five years, but developed a secondary osteo-

and some were in no fit state to withstand major surgery, or even radiotherapy. The anatomical site of the growth was primarily in the cervical esophagus in male patients with secondary spread upwards, whereas in females it was in the hypopharynx or in the junctional region between hypopharynx and esophagus, making an accurate anatomical classification into hypopharyngeal and cervical esophageal types impossible, hence, all cases have been classified as epiesophageal This broad classification does not seem to matter, from a general point of view, as all cases have the same unfavorable outcome, but from the practical one, successful surgical excision is unlikely when the greater part of the upper esophagus is invaded

TABLE XIV

TREATMENT ADOPTED FOR EPIESOPHAGEAL LESIONS

	Prim. Regional Excision (15)	Primary Radio-Therapy (9)	Surgical Exploration (Inoperable)	Palliative Treatment only	Secondary Reg Exc IY P-Thy
Curative (Treat completed)	10	4	1	--	--
Palliative (Treat incompleted)	5	5			1
Totals	15	9	1		1

The surgical treatment adopted has aimed at complete exenteration wherever practicable, *viz*, laryngo-pharyngectomy, partial esophagectomy, thyroidectomy and bilateral neck dissection, followed by either primary, or by secondary, reconstruction On exploration infiltration was found to be more extensive than preoperative clinical and radiological studies suggested (see Table XIV), so the staging adopted in Table XIII is based on the clinical extent of the neoplasm for non-operated cases, and on the operative findings in those submitted to surgery because exploration is needed to determine the extent of malignant invasion with accuracy

Unfortunately, even when regional excision has been seemingly complete, reconstruction offers many problems irrespective of the method of repair adopted Early local recurrence, sloughing of Wookey[14] flaps, postoperative fistula formation

TABLE XIII

EPIESOPHAGEAL CARCINOMA (26 CASES)

No	Sex	Age	Clinical Stage	Histol	Prim Treat	Result 1° Treat	Sec Treat	Final Result
1	F	56	4	Sq	Reg Excision (Incomplete)	Uncontrolled Incomplete Removal	Too advanced	D 4/12
2	M	62	4	Sq	H V T (Incomplete)	Uncontrolled	—	D 12 days
3	F	68	3	Sq	T-R (Incomplete)	Uncontrolled	—	D 8 days
4	F	41	3	Sq	H V T (Incomplete)	Uncontrolled	—	D 2/12
5	M	74	3	Sq	None	—	—	D 9 days before any treat given
6	M	82	3	Sq	H V T	Uncontrolled	—	D 10/12
7	F	80	2	Sq	T R	Uncontrolled	H V T	D 13/12
8	M	63	4	Sq	H V T	Uncontrolled	Reg Excision (Incomplete)	D 11/12
9	F	56	2	Sq	T-R	Uncontrolled	—	D 4/12
10	F	75	3	Sq	T-C (Incomplete)	Uncontrolled	—	D 20 days
11	F	50	3	Sq	Reg Excision	No Ca at P M	—	I D 8/12
12	F	57	4	Sq	Reg Excision (Incomplete)	Sub Clavicular glands involved Not removed	—	R 10/12
13	F	63	3	Sq	Reg Excision	Postmortem No recurrence	—	I D 8/12
14	F	58	4	Sq	Surgical Exploration Inoperable	Uncontrolled	—	D 9/12
15	F	54	3	Sq	Reg Excision	Uncontrolled	—	D 9/12
16	F	46	3	Sq	Reg Excision	Uncontrolled	—	D 7/12
17	M	79	4	Sq	Reg Excision (Incomplete)	Uncontrolled	—	D 5 days Post op
18	F	64	3	Sq	Reg Excision	—	—	D 1 day Post op
19	F	64	4	Sq	Reg Excision	—	—	D 4 hours Post op
20	F	54	4	Sq	Reg Excision (Incomplete)	Died on Table	—	D at operation
21	F	61	4	Sq	Reg Excision (Incomplete)	Uncontrolled	—	D 2/12
22	F	68	3	Sq	Reg Excision	Uncontrolled	—	D 8/12
23	F	69	3	Sq	Reg Excision	Uncontrolled	—	D 6/12
24	M	63	4	Sq	Reg Excision	Uncontrolled	—	D 5/12
25	F	54	3	Sq	Reg Excision	Uncontrolled	—	D 3/12
26	F	54	4	Sq	T C (Incomplete)	Uncontrolled	—	D 7 weeks

Fig 7 Subglottic type of laryngeal cancer This photograph of a laryngectomy specimen shows a typical subglottic tumor arising from the left subglottic space

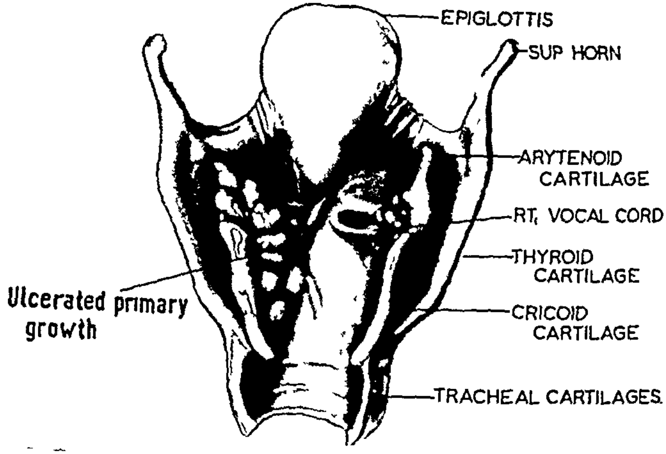

Fig 5 Glottic variety of cancer of the larynx This drawing of a laryngectomy specimen shows a tumor arising from the posterior end of the left cord and extending across the posterior commissure to involve the posterior portion of the opposite cord This type of lesion is classified as glottic

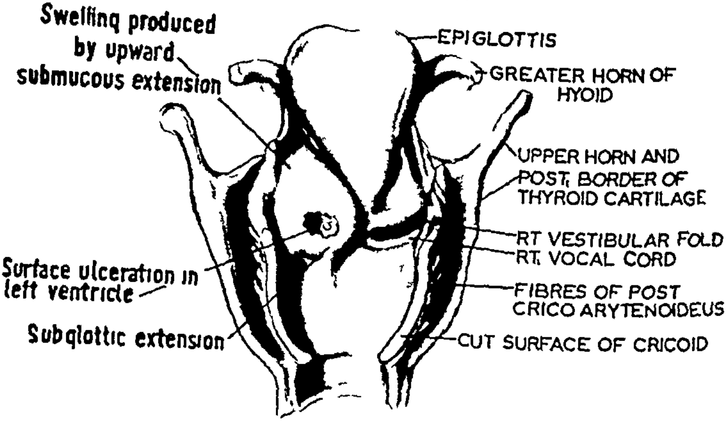
Swelling produced by upward submucous extension
EPIGLOTTIS
GREATER HORN OF HYOID
UPPER HORN AND POST. BORDER OF THYROID CARTILAGE
RT VESTIBULAR FOLD
RT. VOCAL CORD
FIBRES OF POST CRICO ARYTENOIDEUS
CUT SURFACE OF CRICOID
Surface ulceration in left ventricle
Subglottic extension

Fig 6 Glottic type of cancer of the larynx A drawing of a laryngectomy specimen to show a tumor arising primarily from the left cord There is submucosal etension to the supraglottic and subglottic regions

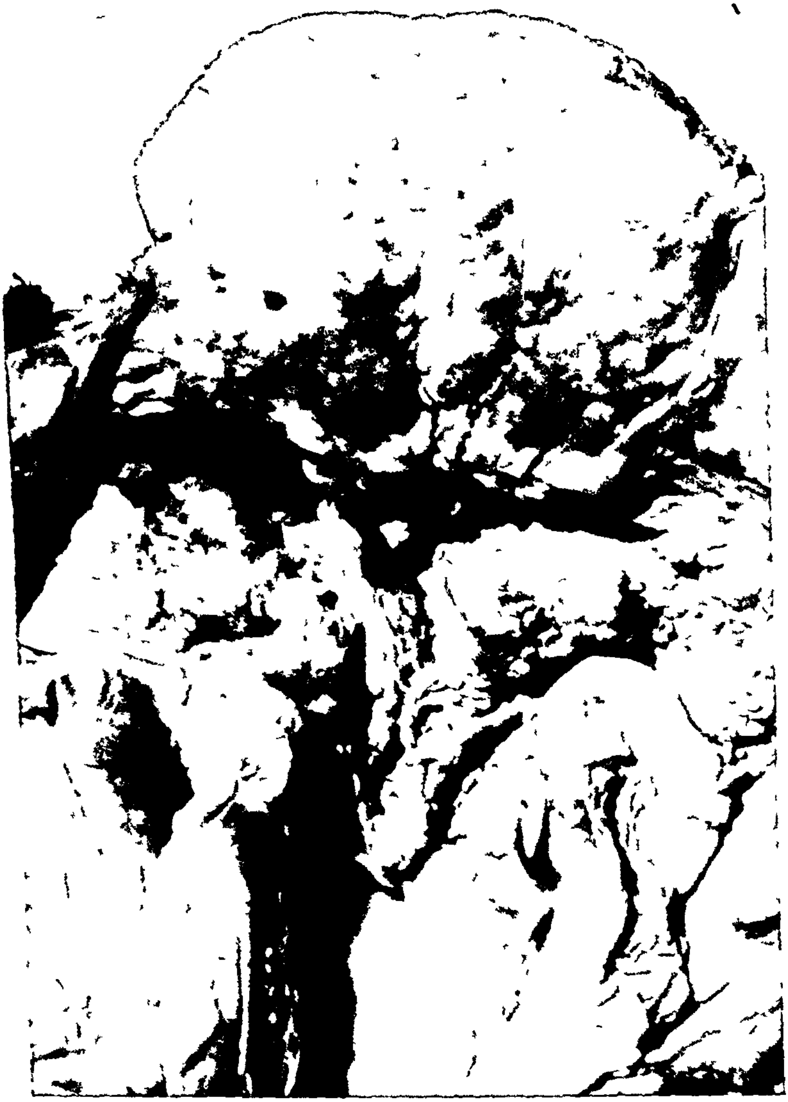

Fig 9 Glosso-epiglottic carcinoma This type is not classified with laryngo-pharyngeal neoplasms A photograph of a specimen showing extensive neoplasm involving the posterior part of the tongue the valleculae the epilarynx and the anterior part of the larynx The epiglottis has been completely destroyed by the ulcerative type of lesion The epilarynx and larynx are involved secondarily by direct extension

and stenosis impose a heavy burden on surgeon and patient alike

Of 16 laryngo-pharyngectomies six were frankly palliative, in that it was impossible to resect the growth with a sufficiently wide margin of normal tissue due to widespread extension to neck tissues, to the esophagus or to inoperable glands Even in the remaining ten, the margin of safety was often far from adequate In over half of those treated by radiotherapy, treatment was incomplete, too As luck would have it, the only two patients who were free of disease died of unrelated causes, one by drowning and the other from bronchopneumonia Careful postmortem examinations were carried out on both Autopsy proved that there was no malignancy at the time of death

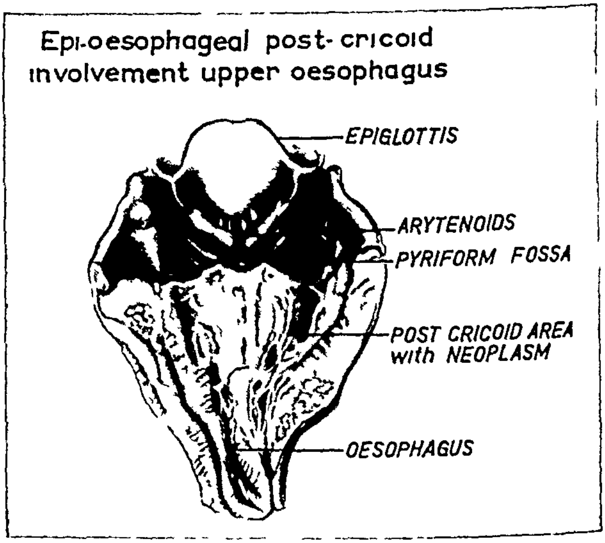
Epi-oesophageal post-cricoid involvement upper oesophagus
EPIGLOTTIS
ARYTENOIDS
PYRIFORM FOSSA
POST CRICOID AREA with NEOPLASM
OESOPHAGUS

Fig 8 Epi-esophageal type of cancer of the laryngo-pharynx This drawing of an operative specimen shows involvement of the hypopharynx and of the cervical esophagus The exact site of origin cannot be stated with certainty hence the grouping together of the hypopharyngeal and cervical esophageal varieties under the all-embracing term, epiesophageal

These gloomy findings do not bear out the more optimistic figures of other authors There is no selection of cases in the above analysis Except in hopeless cases, all possibles have regional surgery does not provide the hoped-for answer to the problem of epiesophageal carcinoma unless the cases can be seen, diagnosed, and treated at a much earlier stage than at present, and that radiotherapy has at least as much to offer in the way of palliation Excluding those dying within the first two months, the duration of life from the beginning of treatment averages six-and-a-half months for patients treated by primary excision and eight months for those palliated by radiotherapy The patient's well-being is often best served by maintaining nutrition as long as possible, and this may necessitate the insertion of indwelling feeding tubes, or gastrostomy

PERORATION

Modern laryngeal surgery owes much to the observations, perseverance and skill of the early pioneers In this connection I would like to pay tribute to my old chief, the late Dr. Lionel Colledge, who first stimulated my interest in laryngeal carcinoma Two decades have passed since that time, some experience has been gained but there is still much to learn

Your Vice-president invited me to deliver this paper, but the honor, and it is a great honor, belongs to my teachers and to my many colleagues The surgeon is only one member of the team engaged in the battle against carcinoma On behalf of the others, as well as on my own, I thank you for the honor accorded us

ACKNOWLEDGEMENTS

I acknowledge with gratitude the help and cooperation of the Royal Marsden Hospital Staff, particularly Dr M Lederman, who has been responsible for the radiotherapeutic treatment of many of the patients, and of my many other colleagues and of those who have kindly referred their cases to the Malignant Clinic of the Metropolitan Ear, Nose and Throat Hospital and to Hillingdon Hospital My thanks are also due to Mr E Stride who has been responsible for the photography, and to Miss B M Becket for the drawings for the illustrations

been given their chance of cure, even when the disease is far advanced The psychological upset produced by laryngectomy is much greater in the case of the female than in that of the male In general, women make a poor attempt to adapt themselves, and rehabilitation is a very great problem The pitiful hurt look of astonished hopelessness on these women's faces after unsuccessful surgery makes one wonder whether the mutilation is worthwhile Certainly, many bitterly resent

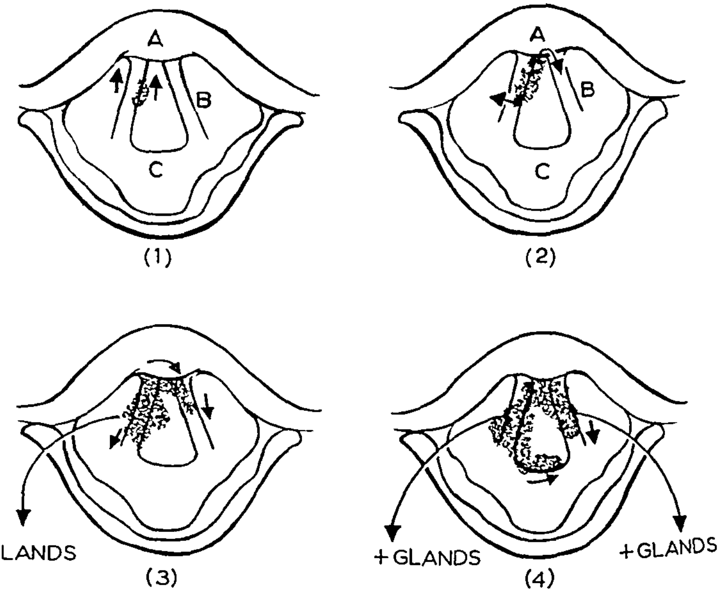

Fig 10 Clinical classification of cancer of the larynx The four clinical stages are diagrammatically depicted Involvement of regional glands is indicated by the letter G See text for details

the surgeon's intervention, which can only be justified if a worthwhile prolongation of useful life is achieved, however good the immediate results of a brilliant and faultless technique may be, it is the ultimate outcome that matters, and the conscientious surgeon remembers that his patient's general well-being takes precedence over his surgical ability If he cannot cure, it should be his aim to reduce and not to increase the sum total of his patient's misery

One is forced to conclude from personal experience that

PATHOHISTOLOGY OF FETAL EARS AFTER MATERNAL RUBELLA*†

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Deafness is a well recognized damage to the offspring when the mother acquires rubella in the first trimester of pregnancy. Statistical data are widely divergent, but a general picture of hearing loss is a proven fact.

Numerous clinical observations place the hearing loss into the framework of a rubella embryopathy. Of outstanding importance is the history as to maternal disease and, even more, damage done to other parts of the fetal organism.

Although there is an abundance of clinical experience, pathological data regarding the hearing organ remain scarce. Since the publication of Schall, Lurie and Kelemen in 1951 from this department, Toendury, in 1952, reported on a fetus of 80 days and a premature, Nager, 1952, added three histologically examined cases, and Lindsay, et al., in 1953, five more. It seems that the cases investigated so far are divided equally between embryonic hearing organs and those autopsied in infancy (ten each). The last five years have not brought any new contribution to the histopathology of the hearing organ in rubella.

The four cases presented here came from therapeutical interruptions of pregnancies of mothers who had rubella in early pregnancy. The collaboration of Dr. Kurt Benirschke, pathologist of the Boston Lying-In Hospital, made this material available. His discussions of the antecedents and of the connection with the data of the pathological examination

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ELEVENTH CONGRESS OF THE INTERNATIONAL ASSOCIATION OF LOGOPEDICS AND PHONIATRICS

Those unable to attend this Congress but who would like to secure a copy of the Report of the Proceedings can obtain it at the reduced rate of *seventeen shilling and sixpence* (17/6) by ordering it in advance, enclosing payment, from the Secretary, before August, 1959 Secretary's address Peggy Carter, L C S T, 46, Canonbury Square, London, N 1

Maculae and cristae were fully developed, and the organ of Corti, under a rolled up tectorial membrane, was already a mound elevated above the basilar membrane The degree of fixation was not sufficient clearly to distinguish cytological details The membrane of Reissner was in a normal position The dura was thin and without hyperemia

Left Temporal Bone With findings similar to the right side the following can be added Under the dura, as in a few other locations, a minimum amount of blood was scattered These small extravasates were, in the inner ear, more conspicuous by their location than by their extent Even a few red blood corpuscles, when in contact with a cupula, caused destruction of the same (see Fig 1)

With the ductus reuniens somewhat dilated, dilatation became more conspicuous in the perilymphatic cisterna, sacculus and utriculus were somewhat compressed by this perilymphatic bulging The saccus endolymphaticus seemed to be dilated, but, as it was open in the specimen, no deduction could be made regarding its original state For the same reason, the cochlear aqueduct could not be traced in its entire length Corti's organ, on both sides lagged in evolutionary degree behind the already fully evolved vestibular end organs It formed a distinct mound in the basal and in the middle turn, but in the apical turn it still remained an undifferentiated pseudostratified layer of neuroepithelial cells (see Fig 2) The spiral nerve was already connecting Corti's organ to the spiral ganglion in the connective tissue modiolus

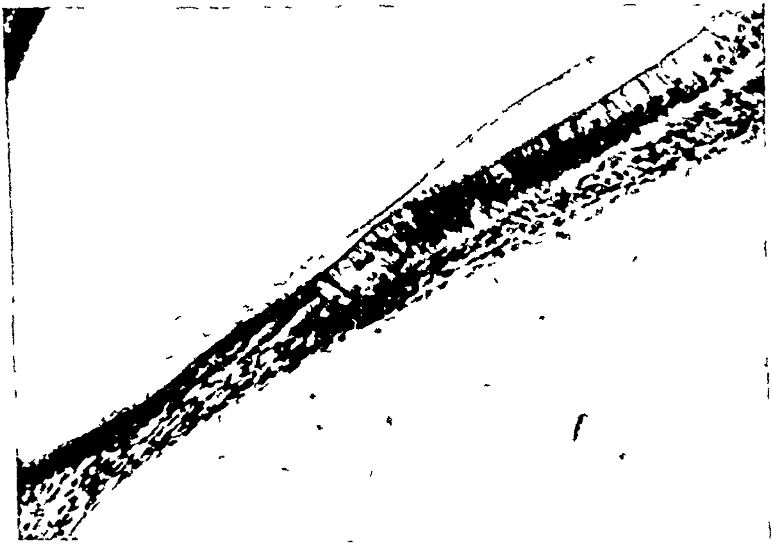

Fig 2 Case 1 Left side Heidenhain-Mallory X250 Organ of Corti in apical turn row of undifferentiated cells, tectorial membrane adherent

Case 2—Unit No 37932 The 29 year old mother suffered German measles in the sixth week of pregnancy which was her third Therapeutic abortion was done at the sixty ninth day by ovum forceps and curette, with the female fetus removed in pieces The estimated crown rump made it possible to put the ear findings into the framework of general rubellar embryopathy

CASE HISTORIES

Case 1—Unit No 36115 The 23-year old mother had German measles in the tenth week of her second pregnancy Hysterotomy was performed and a female fetus of a crown rump length of 149 mm, corresponding to 17½ weeks of gestation was removed

No gross malformations were found, the histopathological examination of the brain by Dr Samuel P Hicks, resulted in normal findings

The right temporal bone was sectioned after embedding in paraffin the left was processed by the usual celloidin technique

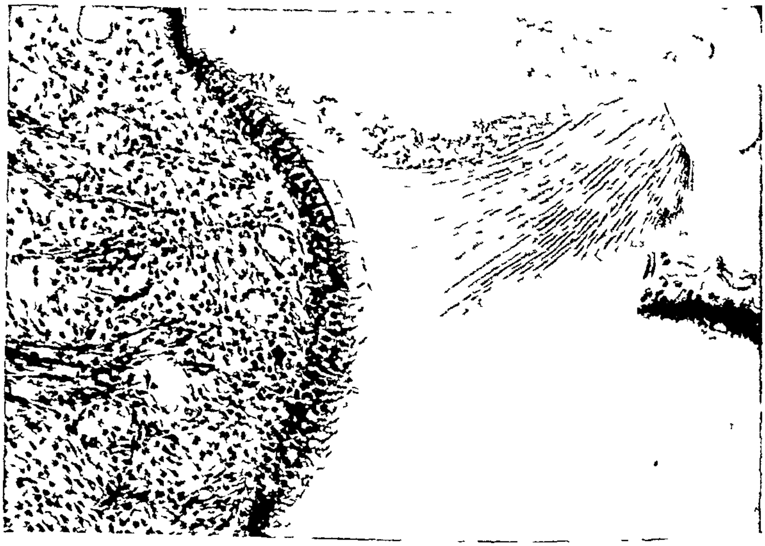

Fig 1 Case 1 Left side Heidenhain-Mallory, X250 Ampullar crista the cupula eroded one side, by extravasate

Right Temporal Bone The tympanic membrane was formed, with the regular strip along its tympanic surface free of mesenchyme, while mesenchyme completely filled the middle ear and the perilymphatic spaces of the inner ear The ossicles were cartilaginous, with beginning ossification in the long process of the malleus The mesenchyme of the middle ear showed a considerably looser structure than that of the inner ear The annular ligament of the stapes was clearly discernible at its medial circumference laterally the plate was still fastened to its frame, cartilage to cartilage The periosteal layer of the cochlear capsule was represented by a thin shell but with intensive osteogenesis along its external surface The marrow spaces of the endochondral layer were very wide The finely drawn endosteal layer showed hardly any ossification The modiolus was still entirely of connective tissue, the endolymph spaces of the vestibulum and cochlea were practically free of mesenchyme

The ears went through the usual celloidin embedding, the right side was sectioned in a vertical, and the left in a horizontal plane

Right Temporal Bone The specimen contained only the inner ear and, up to section No 600, a narrow strip of middle ear For the remaining 200 sections only the inner ear was present The ossicles were seen only in part

Left Temporal Bone Practically only the inner ear was present

Both ears showed similar findings which can be described together

The dura was normal without hyperemia Very small extravasates were scattered in a few regions but not around the sensory end organs, and not in the inner meatus An exception was a small fibrous organized thrombus, not of recent formation, originating from a large vessel in the vestibular portion of the spiral ligament in the middle turn of the left cochlea (see Fig 4) The subarcuate fossa, filled by mesenchyme, was bridged over by normal dura, which did not descend into the depth of the fossa The labyrinthine capsule was a solid cartilaginous block although invaded by osteogenic buds In the capsule of the vestibulum and of the cochlea ossification was in progression The periosteal and endosteal layers were formed everywhere The endochondral layer was a mesh of large vascular connective tissue channels with trabeculae of bone and cartilage and massive invasion of marrow tissue Osteoblastic activity was intensive in all three layers Vestibular and cochlear portion of the otic capsule were in the same developmental stage, while the modiolus of the cochlea was still completely formed by connective tissue Maculae and cristae were fully developed (see Fig 5) The macula sacculi of the right side was covered by a foamy precipitate that was not present over the three remaining maculae

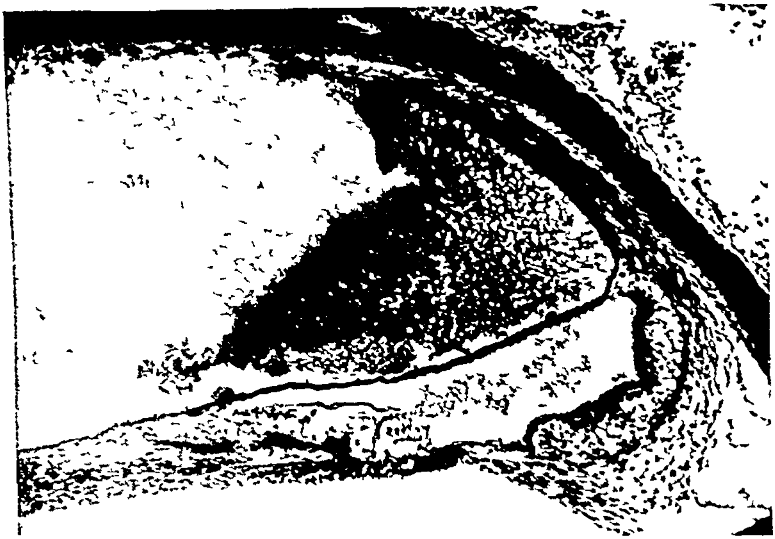

Fig 4 Case 3 Left side Heidenhain-Mallory X125 Fibrinous thrombus in scala vestibuli of middle turn in cochlear duct still mesenchyme

length was 70 mm, corresponding to nine weeks gestational age Sections of the placenta and other tissues of the embryo showed degeneration despite persistence of trophoblastic mitoses The decidua showed areas of necrosis

In one fragment of the cranial base, parts of the cochlea and the intact inner acoustic meatus were found The cochlear capsule was entirely cartilaginous without a vestige of ossification The vestibular and tympanic scalae were filled with mesenchyme, and the cochlear duct was free The tectorial membrane was smoothly stretched over the organ of Corti The latter was represented in the apical turn by a straight layer of neuroepithelial cells In the basal and the middle turns the basal portions of the neuroepithelial cells seemed to be embedded into the substance of the basilar membrane (see Fig 3), the latter not quite differentiated from the mesenchymal mass of the tympanic scala Reissner's membrane was in a normal position An atypical growth, an epithelial funguslike formation, was seen in what could be identified as a portion of the utricle

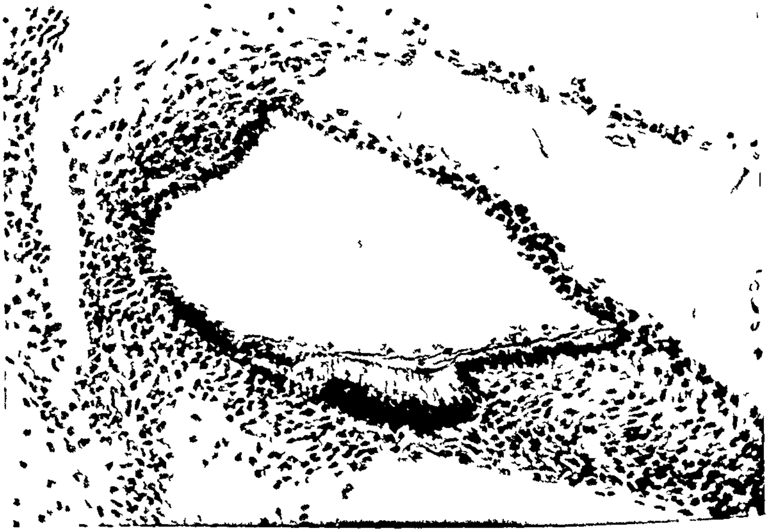

Fig 3 Case 2 Heidenhain-Mallory, X250 Contents of the cochlear duct middle turn, free of mesenchyme mesenchymal masses still in tympanic and vestibular scala

Case 3—Unit No 38345 A healthy 25 year old primigravida had rubella at two and a half months of her pregnancy while working as a domestic in a household in which three children had rubella around this period The classical eruption was accompanied by retroauricular node enlargement Abdominal hysterotomy was done in the eighteenth week of gestation A male fetus of 200 mm crown rump length was removed At necropsy the tissues were macro and microscopically unremarkable, save for obvious immaturity of a degree consistent with the probable age of gestation The disparity between measurements and the probably stated date of the conception suggested that miscalculation of approximately one month was made by the mother the retroauricular region She had no fever and no respiratory or other symptoms By abdominal hysterotomy a male fetus of crown rump length of 110 mm corresponding to fifteen weeks gestational age was removed On dissection, no gross anomalies were found The immature placenta showed whole areas of degeneration and, under the microscope, old marginal infarction The brain was normal Microscopic examination of the eyes (Dr Taylor R Smith) showed rubellar cataracts

The two ears were obtained in one block which was sectioned in a frontal plane with resulting paramodiolar sections through the cochlea

The findings were identical for both sides Within the middle and the inner ear there was no vestige of ossification, although in the temporal squama it was well progressed

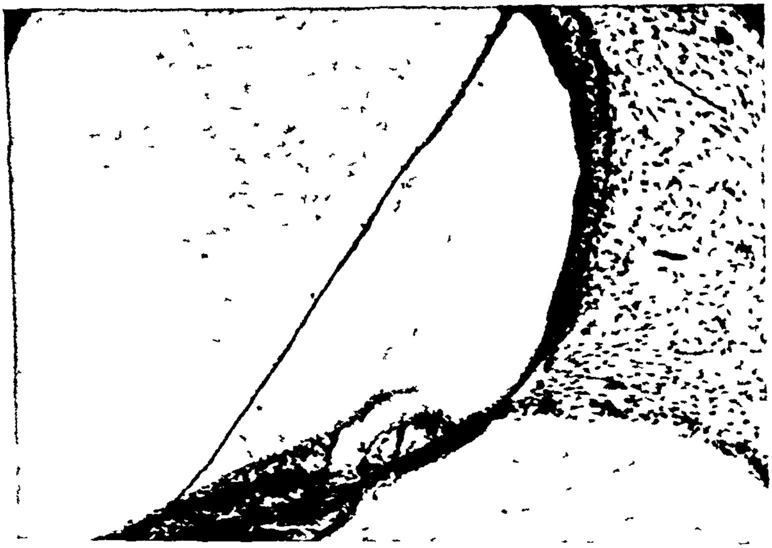

Fig 6 Case 3 Right side Heidenhain-Mallory X175 Organ of Corti in middle turn Tectorial membrane elevated like being pulled up by shrinking mesenchymal band mesenchyme still fills the vestibular and the tympanic scalae

Ossicles and otic capsule were uniformly cartilaginous, with a connective tissue modiolus in the cochlea Maculae and cristae were well developed, the latter together with the cupulae The organ of Corti was represented in the apical turn by a straight row of neuroepithelial cells while arching of the papilla started in the middle and the basal turn The nerve connection from the organ of Corti through the spiral ganglion to the VIIIth nerve was formed The stria was already vascularized to a certain extent The mesenchyme showed different character in different locations In the middle ear including the windows, it was a dense net of bipolar spindle cells with few vessels, the cisterna perilymphatica was filled with an amorphous dense, foamy mass The perilymph spaces of the vestibule contained both the astrocytic and the amorphous type, there were vacuoles in the astrocytic field, which were filled with a mass of the amorphous type The latter type formed the content of the vestibu-

The lumen of the saccule and utricule was normal, or somewhat depressed The evolutional sequence of the organ of Corti was normal In the basal turn a high mound was formed around the tunnel, in the middle turn (see Fig 6) the mound was of similar elevation but with less structural differentiation In the apical turn the arching of the organ of Corti was on its way, with the neuroepithelium still undifferentiated The tectorial membrane was detached in the basal turn, adherent in the middle and apical turn, at one point (see Fig 6) it was pulled in the direction of Reissner's membrane by a shrinking mesenchymal band The mesenchyme disappeared from practically all the endolymphatic spaces In the remaining regions it showed different aspects A fibrous structure filled the niches of the oval and the round window, while the content of the cisterna under the stapedial plate was an amorphous mass The scala vestibuli and tympani were filled by the same amorphous type while both kinds, fibrous and amorphous, were present in the perilymphatic spaces of the semicircular canals Here the fibrous mesh lined the canal walls, and in the amorphous mesenchymal masses cysts or vacuoles appeared Conspicuous was the scarcity of cells and vessels The mesenchyme in the perilymph of the vestibulum suggested the definite trabeculi, and the cysts and vacuoles reminded one of the process of disappearance of the mesenchyme around term

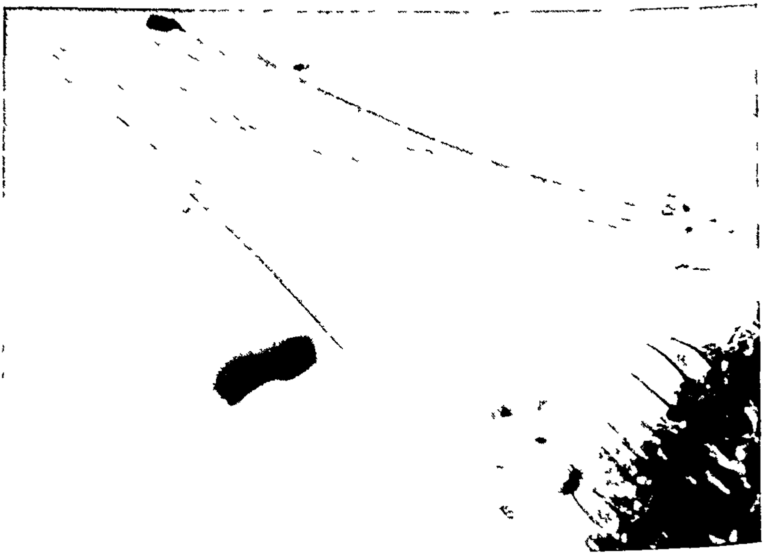

Fig 5 Case 3 Left side Heidenhain-Mallory X450 Crista with cupula intact

Ossification started in the ossicles, cortical in the incus, and being present, to some measure in the stapedial plate The annular ligament was already outlined, although the plate was still inserted in its frame cartilage to cartilage

Case 4—Unit No 38757 This was the third pregnancy of a 28 year old mother who contracted rubella at about the fourteenth gestational week, with a rash over face and body for two days and an enlarged node in in the seventeenth, seventeen-and-a-half and eighteenth week respectively In three cases both temporal bones were obtained for further study, and in only one was the material reduced to a fragment The main data are compiled in Table I

The findings can be discussed around three points of importance mesenchyme, ossification, and sensory end organs

The *mesenchyme* showed the same picture throughout the series In the middle ear there was an astrocytic fibrous mesh, comparatively loose In the inner ear two kinds of mesenchyme were found a fibrous mesh enclosing vacuoles filled by an amorphous type in the perilymphatic spaces, with exception of the cisterna under the stapes plate, which was filled exclusively by amorphous, homogeneous masses The endolymphatic spaces in the vestibule and in the cochlea were practically free of mesenchyme, or showed only insignificant isolated remains of the latter It is felt that the behavior of the mesenchyme was entirely normal

TABLE I

HOSPITAL NUMBER	*MOTHER*			*RUBELLA*	*INTERRUPTION*		*FETUS*		TEMPORAL BONE	ANOMALIES OUTSIDE HEARING ORGAN
	AGE	GRAVIDITY	PARA	GESTATIONAL WEEK	GESTATIONAL WEEK	OPERATION	SEX	CR *mm*		
36115	23	2	1	10	17 1/2	HYSTEROTOMY	♀	148	RT & LT	NONE (INCLUSIVE BRAIN)
37932	29	3	2	6	10	CURETTE	♀	70	FRAGMENT	NO INFORMATION
38345	25	1	0	10	18	HYSTEROTOMY	♂	200	RT & LT	NONE (INCLUSIVE BRAIN)
38757	28	3	2	14	17	HYSTEROTOMY	♂	110	RT & LT	RUBELLAR CATARACT BRAIN NORMAL

The *ossification process* proceeded at the expected rate in all three layers of the otic capsule The progress corresponded to the gestational period Case 4 was an exception, here, although the seventeenth calculated week was reached, no lar and tympanic scalae, sometimes dense, sometimes rarefied, but always without cells or vessels The endolymph spaces were practically free of mesenchyme within the entire otic capsule The tectorial membrane was rolled up over the arching papilla in the middle and in the basal turn

DISCUSSION

Technical Remarks As all material was obtained from surgical interventions, with immediate fixation of the specimen, no postmortem changes could develop Deficiencies in the histological pictures must all have originated during fixation or other phases of the preparation for microscopy The staining was done with hematoxylin and eosin, with Heidenhain-Mallory, Gomori impregnation, for polarization unstained sections were mounted Examination was done in full and polarized light and under phase

An important point in judging the resulting pictures was the presence of hemorrhage This was reduced to a minimum, thanks to the careful operative procedures which at the same time excluded any traumatic irritation Even in Case 2, where the removal was done by curettage, signs of bleeding were absent from the fragment which came to examination A factor to be remembered in judging the histological picture is the possible effect of a number of drugs administered before the operation and in connection with the anesthesia

Where temporal bones of children with deafness were examined the functional tests of hearing could give a clue if changes by maternal rubella were present As this is not the case with fetal material, one cannot be sure whether a case belongs to the group where deafness possibly could have developed Under these circumstances possible malformations in other organs are of importance In Cases 1, 3 and 4, the brain showed histopathologically no abnormalities, in Case 4 rubellar cataracts were diagnosed, while the curette case (No 2) did not lend itself to further observations

An advantage of the material presented here is its uniformity The mothers belonged to the same age group, between 23 and 29 years, and rubella had developed at approximately the same gestational periods Removal was done between the tenth and the eighteenth gestational week, with three cases belong to the rarities and should not be given further consideration

All in all, insofar as histopathological changes were found within the ear, they are not sufficient to be a cause of functional loss in the peripheral organ This means that, as in other viral conditions, central neural damage may be present in rubella also

Toendury emphasized an evident organ-affinity of the rubella virus with destructive effects, the lesions localized in certain structures of the cochlear duct, probably beginning in the stria vascularis Nager joined in this explanation, a remarkable fact in his tabulation is the presence of otitis media in all infantile cases Lindsay, et al, found in one of their five cases, a bilateral sacculo-cochlear type of pathology, with thickening and distortion of the wall in the saccule, and adhesions to the macula, with corresponding areas of macular degeneration, and, in the cochlear duct, malformations of the tectorial membrane and Corti's organ, the reduction in the extent of the stria vascularis has been interpreted as an indication of the virus effect, permitting a greater concentration of the virus irritant in the endolymph within the cochlear duct and the saccule

Schall, Lurie and Kelemen presented as an explanation of arrest of development and vascular lesions a "monistic theory" According to this the vessels are the first to suffer, and the lack of nutrition is followed by developmental arrest, vulnerability of the vessels shows its consequences during pregnancy or any period of strain, at delivery or at any perinatal or postnatal point

Through careful surgery (hysterotomy) in three of the four cases presented here, hemorrhage was reduced to a possible minimum, with only one region of one case (see Fig 4) showing a somewhat conspicuous extravasate

Toendury stressed repeatedly, as did others, the difficulty in evaluating normalcy or pathology in the histological picture of the elements of the inner ear Unquestionably great caution is here in order signs of ossification were seen in the cartilaginous walls of the middle and the internal ear, while ossification was already progressing in the squama

The *sensory end-organs,* together with their neural apparatus, in all four cases were in a stage wholly corresponding to their gestational age The cristae, including their cupulae and the maculae including the otoconial layer, were already fully developed The organ of Corti was an undifferentiated neuroepithelial layer in the apical turn, but as it progressed toward the base a more and more conspicuous arching pointed in the direction of development into the definite full mound The stria showed no signs which could be interpreted as an arrest or even degeneration The tectorial membrane was still firmly adherent to the surface of the papilla, except where it was rolled back as a result of preparation With the end-organs of the vestibulum fully formed, and with the organ of Corti showing the expected state of evolution in the different turns, no signs of arrest or degeneration could be noted Imperfections in the presentation of the Corti papilla could all be charged to the preparatory process, but they could be judged with sufficient certainty to leave no doubt about the evolutional stage

Hemorrhage might give a clue for possible functional damage within the hearing organ It can be supposed that the viral attack results in a vulnerability of the vessels resulting in extravasation One such condition was found in Case 3 in the form of an organized thrombus Very small extravasates can be deleterious when in strategic locations The cupulae can be eroded by contact with the smallest amount of blood (see Fig 1) , in the cochlea a minimum extravasation in the basilar membrane underlying Corti's organ, or in the vascular stria, may have far reaching consequences

Even without exaggeration of the role of extravasates, including their probable disappearance by absorption, it remains to be assumed that a supposed fragility of the vessels will show deleterious consequences at any period of strain, during gestation, around the delivery or in postnatal life An epithelial formation in the inner ear, as found in Case 2, does not

TOENDURY, G Zur Kenntnis der Embryopathia Rubeolica, Nebst Bemerkungen ueber die Wirkung Anderer Viren auf den Keimling *Geburtshilfe und Frauenheilkunde*, 12 865 888, Oct, 1952

TOENDURY, G Zur Wirkung des Erregers der Rubeolen auf den Menschlichen Keimling *Helvetica Paediatrica*, 7 2, 105 135, 1952

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Most of the hitherto communicated cases remained within the frame of normalcy. Assuming the basic importance of vascular damage, the role of the central nervous system is of significance as responsible for the functional loss; however, in three of the present cases the brain was examined and was found to be normal.

SUMMARY

Four cases of interrupted pregnancy between the tenth and the eighteenth week are reported. The indication for surgery, hysterotomy in three cases and curettage in one, was rubella of the mother in early pregnancy. Both temporal bones were examined in sectional series in the cases with hysterotomy and so was a fragment from the curette case.

Sporadic pathology was found: a massive hemorrhage in a vestibular scala (see Fig. 4), some blood mixed in the mesenchyme of the perilymph (see Fig. 1), band fixation of a tectorial membrane to the membrane of Reissner (see Fig. 6).

Adding the present report to a previous one by Schall, Lurie and Kelemen, from this department, six cases failed to show any aural histopathology definitely responsible for the well established fact that hearing loss in the progeny frequently follows maternal rubella.

For the time being the most promising clue may be vascular fragility, leading eventually to abnormalities. In the central as in the peripheral hearing organ, the vascular damage may become a factor at periods of strain: during gestation, at delivery, at any point of perinatal or postnatal life. Study of viral effects on blood vessels may give a clue to a pathological basis for deafness as part of rubellar embryopathy.

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CONSIDERATION OF CHANGE IN PRESENT POLICY OF PERFORMING TONSILLECTOMIES AND ADENOIDECTOMIES DURING SUMMER MONTHS*†

ALBERT B SABIN, M D.,
(By Invitation),

Cincinnati, O.

The question before us is whether the widespread use of Salk vaccine and the resulting diminution in the incidence of paralytic poliomyelitis justify a change in the present policy of prohibiting the performance of elective tonsillectomies and adenoidectomies during the Summer months, or so-called "poliomyelitis season" First, we shall consider the grounds on which these operations have been prohibited and then analyze the manner in which the factors under consideration may have been altered by the use of Salk vaccine

These operations have been prohibited during the "poliomyelitis season" because of an increased risk of development of bulbar poliomyelitis This increased risk is believed to be due to

1 Increased dissemination of polioviruses during the "poliomyelitis season "

2 Actual contamination of severed pharyngeal nerves with virus either already present in the throat at the time of the operation, or localizing in the wound from the blood shortly after the operation

The first question that we must ask, therefore, is whether there is any evidence that the widespread use of Salk vaccine has diminished the dissemination of polioviruses during the "poliomyelitis season " The answer is that all the data gathered thus far indicate that the antibody produced by Salk vaccine does not prevent extensive multiplication of the virus

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in the intestinal tract, and that dissemination of the virus is readily accomplished by children with an adequate immune response to the vaccine. Earlier experimental[1,2] and field studies[3,4,5] were carried out in persons who had received only one or two doses of Salk vaccine. During the past year we[6] have completed a study of 26 children, whose antibody status was known prior to the inoculation of four doses of Salk vaccine over a period of 14 months, and who were subsequently fed attenuated polioviruses. This study showed that the immunity produced by the four doses of Salk vaccine had no effect either on the amount or duration of virus excretion in the stools, and that these immune children were capable of infecting other fully vaccinated children who were in contact with them in an institution under conditions particularly suitable for fecal contamination. Recent studies by Fox Gelfand and their associates[7] established the capacity of children, who had received three doses of Salk vaccine, to disseminate naturally acquired polioviruses as well as orally administered attenuated strains under ordinary home conditions.

Regarding the special problem of tonsillectomies and adenoidectomies, we are especially interested in how polioviruses localize and multiply in the throat, and how the immunity produced by Salk vaccine may influence either the localization or the multiplication of virus in the posterior pharyngeal wall. Studies carried out in 1955 indicated that poliovirus could be demonstrated in the posterior pharyngeal wall of 83 per cent of a group of 23 patients with clinically diagnosed poliomyelitis tested within two to six days after onset of first symptoms.[8] This study also established the absence of virus multiplication in the mouth and nose where only traces of virus were found in four of this group of 23 patients. Experimental studies on human volunteers who swallowed various strains of attenuated polioviruses, established the fact that with viruses, which have no demonstrable viremic phase, the localization and multiplication of virus in the throat is a function of the amount that is swallowed.[1c,8a] The word swallowed must be emphasized here, because different results can be obtained when the virus is swabbed on the throat or squirted directly on it. To obtain an incidence of about 80 per cent localization in the throat, such as was found in the patients with clinical disease, it was necessary to feed one million or more tissue culture infective doses of the attenuated strains. The question, therefore, arises whether the patients with naturally acquired clinical disease actually swallowed such large amounts of virus, or whether the high incidence of virus in their throats may be accounted for by another mechanism. The maximal amounts of virus excreted by naturally infected patients, as well as by children experimentally infected with attenuated strains, is about one million tissue culture infective doses per gram of stool.[1c,8a] A person would, therefore, have to swallow at least a gram of stool to obtain such a large dose, which seems most unlikely. The amount of virus that can be obtained by swabbing the throat at the peak of multiplication is in the range of 1,000 to 100,000 tissue culture infective doses, and the absence of virus from the mouth, saliva and nose except in trace amounts in rare instances, indicates that the virus in the throat cannot be a source of infection under normal circumstances. While it is possible that with virulent epidemic strains, less virus may be necessary to initiate multiplication in the throat, it is also possible for such strains to localize in the throat secondarily after they have multiplied in the intestinal tract and other extraneural tissues and produced a viremia. For viruses localizing in the throat secondarily from the blood stream, even minimal amounts of antibody produced by Salk vaccine should be sufficient to block such localization.

In a study carried out by Wehle, et al.[9] on familial associates of paralytic cases, virus was recovered from 6 per cent of 52 pharyngeal cultures obtained from 14 children who had received one or two doses of Salk vaccine, as compared to 17 per cent of 88 pharyngeal cultures from 23 unvaccinated children.

Davis et al.,[4] who carried out a similar study during the 1956 Chicago epidemic, limited the analysis of their results to ten families in which at least one member was found to have virus in the throat. Among 16 unvaccinated children, virus was recovered from the throat of eight, while among 16 vaccinated children only four yielded virus—one virus isolation was obtained from six children who had one dose, three isolations from seven who had two doses, and none from the three children who had had three doses. While the interpretation of such studies is limited by the fact that one does not know the immune status of the unvaccinated control group or of the vaccinated children prior to inoculation of Salk vaccine, they, nevertheless, show that under natural modes of transmission, virus can be found in the throat of some children who have had only one or two doses of Salk vaccine.

Horstmann et al.,[2] who fed 25 million tissue culture infective doses of the Type 1, L Sc attenuated strain to children immunized by two doses of Salk vaccine, demonstrated viral multiplication in the throat of six of the seven children tested. It should be noted, however, that the dose of virus was very large, and with one exception the titers of antibody were 16 or less. It is known that for antibody to appear in the nasopharyngeal secretions the titer in the blood needs to be in the range of 32 or higher. During the course of our study[1] on children who had received four doses of Salk vaccine, we tested for virus in the throats of nine children, four of whom received about six million tissue culture infective doses of Type 1 attenuated virus, and five about 2.5 million doses of Type 3 in a teaspoonful of syrup (see Table I). On the basis of other tests in adult volunteers, without homotypic antibody, one could have expected to find virus in the throat of about 80 per cent after ingestion of such a dose, however, despite repeated tests no virus was recovered from the throat of any of these children, although all of them excreted virus in the stools for a period of two weeks or longer. Since two of these children had no demonstrable antibody and one had only a titer of four at the time of virus feeding, and yet also had no demonstrable virus in the throat, one may question the significance of the negative findings in the other six children with high titers of antibody. Fox, Gelfand and their associates[7] used aliquots of the same attenuated strains in a study on 16 unvaccinated medical students without homotypic antibody as well as on 14 who had received three doses of Salk vaccine. Although their study is not comparable to ours, because they squirted the virus directly on the throat, the results, nevertheless, indicated that pharyngeal infection occurred only in those whose antibody was either not demonstrable or in titiers not higher than 1 8 by their method of testing Thus, in their tests with Type 1 the virus multiplied in the throat of all six unvaccinated students without homotypic anitbody, and in only two of six vaccinated students who excreted virus in the stools after receiving 32,000 to 800,000 tissue culture infective doses

The conclusion appears to be warranted that when Salk vaccine of *sufficient potency and dosage* is given to produce an adequate antibody response, one may expect to prevent localization of virus in the throat either by prevention of deposition from the blood stream, or by neutralization at the time of primary implantation Since the increased risk of tonsillectomies and adenoidectomies during the "poliomyelitis season" is believed to result either from the presence of virus in the throat at the time of operation or from subsequent localization in the wound of virus that might be circulating in the blood, one may be justified in carrying out such operations on those who have been successfully immunized with Salk vaccine, however, in drawing up specific recommendations regarding those who may or may not be submitted to

TABLE I

Presence of Poliovirus in Throat Swabs and Stools from Children, Who Lacked Indicated Type of Antibody Prior to Receiving 4 Doses of Salk Vaccine During a Period of 14 Months, and Then Were Fed Large Doses of Attenuated Poliovirus 3 Months After the Fourth Dose

Virus Fed	Name	Antibody Titer just before Feeding	Presence of Virus in Throat Swabs	Presence of Virus in Stools	Antibody Titer after Feeding
Type 1 (L Sc, 2 ab) $10^{6\ 8}$ TCD_{50}	Kee	<4	0*	+	512
	O'Ha	128	0	+	2048
	Bac	256	0	+	1024
	Seh	256	0	+	2048
Type 3 (Leon, 12 a_1b) $10^{6\ 4}$ TCD_{50}	Abb	<4	0	+	1024
	Bai	4	0	+	512
	But	64	0	+	256
	Cam	64	0	+	4096
	Gau	64	0	+	256

0 = No virus detected in swabs taken 3 5 7, 10 14 21, and 28 days after feeding of virus

+ = Virus multiplication for 2 weeks or longer

TABLE II

Antibody Status Among Children, Originally Lacking Indicated Type of Antibody, at Different Times During and After Inoculation of 4 Doses of Commercially Produced Salk Vaccine Between Nov 7, 1956 and Dec 23, 1957

Antibody Type Absent Prior to Salk Vaccine	No of Children Tested	Per Cent Without Antibody in Indicated Category at Indicated Time					
		Category	1 month after 2nd Dose	1 month after 3rd Dose	5 months after 3rd Dose	2 weeks after 4th Dose†	3 months after 4th Dose
1	9*	No Antibody	56	22	44	12	25
		<32	78	22	78	25	25
3	19	No Antibody	47	42	53	0	11
		<32	68	63	84	11	11

*One of these children did not receive the 4th dose and the percentage incidence after the 4th dose is based on 8 children

†An especially selected lot of vaccine of high antigenic potency was used for the fourth dose

NOTE The antibody results given here were obtained by the highly sensitive pH (metabolic inhibition) test The incidence of negative results and low titers was much greater when delayed readings in the cytopathogenic test were used such operations during the "poliomyelitis eason," one is faced with the decision as to what constitutes adequate immunization with Salk vaccine The Salk vaccine produced commercially since the adoption of the more stringent safety tests has often been of poor potency, especially for Types 1 and 3[10,11] The results that we[6] obtained in a group of five to ten year-old children, who received four doses of commercially produced Salk vaccine between November, 1956, and the end of December, 1957, prior to a test on the effect of feeding attenuated polioviruses are summarized in Table II It should be noted that with one exception all of these children already had naturally acquired immunity to one or two types of virus and, therefore, would be expected to respond better to Salk vaccine of poor potency than "triple-negative" children It can be seen that even three doses failed to produce antibody in a considerable proportion and that five months after the third dose, 44 per cent were without demonstrable antibody for Type 1 and 53 per cent without Type 3 When a serum titer of 32, the minimum level that may be expected to yield detectable antibody in the nasopharyngeal secretions, was taken as the standard, 78 per cent in the Type 1 group and 84 per cent in the Type 3 group had titers of less than 32 five months after the third dose The fourth dose of vaccine, consisting of an especially selected lot of high antigenic potency, produced an antibody response in all but one of the children within two weeks, which in a few instances disappeared again within three months

In the light of these considerations and results, I drew up the following recommendations regarding tonsillectomies and adenoidectomies during the "poliomyelitis season," which were adopted by the Cincinnati Board of Health and followed during the 1958 season

Emergency operations on the throat can be performed during the so-called "polio season" without reference to the vaccination status of the patient

For *elective* tonsillectomies and adenoidectomies, the term "elective" is understood to mean an operation that can be postponed for a period of at least two weeks without harm to the patient

In such cases, operations can be performed during the "polio season," providing that the patient has had at least three inoculations of polio vaccine, the last dose having been administered not more than six months prior to the date of operation

If the interval between the last dose of vaccine, regardless of the number of doses previously given, and the date of operation is greater than six months, another dose of vaccine should be administered two weeks prior to the operation

It was also agreed that if a high incidence of poliomyelitis appeared in the community, these recommendations may be withdrawn The main objection to these recommendations may be the unpredictability of the immune status of triply-negative children six months after three doses, or two weeks after a fourth or fifth dose of Salk vaccine of current manufacture I assume that laryngologists prefer the Summer season for necessary elective tonsillectomies or adenoidectomies not only because of convenience, but also because of the decreased risk of severe postoperative infections that are more likely to occur during the cold months of the year when polioviruses disseminate less but pathogenic bacteria—not all of them readily controlled by antibiotics—more The physician is thus faced with the problem of weighing risks

In checking on the number of tonsillectomies and adenoidectomies that were performed in Cincinnati hospitals during the period of June 1 to November 1, I found that 684 such operations were performed in 1957 before the above-mentioned recommendations were adopted, and 1,315 in 1958 when the hospitals required a certificate indicating that the patient had been vaccinated in accord with the recommendations It seems to me that even though the proposed number and intervals of Salk vaccine injections cannot assure the desired immune status in all children, it was better to have this additional protection than to perform such operations without reference to the vaccination status of the patient as was done in Cincinnati in 1957, and undoubtedly in other parts of the country as well In view of the 1958 experience in the United States, indicating that a certain proportion of the reported paralytic cases occurred in children who have had three doses of Salk vaccine, and in view of the fact that no action has as yet been taken to provide Salk vaccine of uniformly adequate potency, I would change my 1958 recommendations to require a minimum of four doses of vaccine, and still another dose two weeks prior to operation if the interval since the last dose is three months or greater. I would still favor prohibition of such operations in communities in which poliomyelitis is epidemic. It should be pointed out that polio viruses disseminate also during the cold months of the year, although at a lower rate than during the Summer months. Accordingly, when operations on the throat are performed during the cold months of the year, the risk of a complicating bulbar poliomyelitis is also not eliminated with complete certainty.

Some may not agree with the requirement of at least four doses of vaccine and the inoculation of another dose two weeks before the operation, if the interval since the last dose is three months or greater, because they believe that the currently available Salk vaccine is usually better than our data indicate, while others may be opposed to any change in the present policy of performing these operations during the Summer season until uniformly effective vaccine is available.

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OUTLINE OF THE MANDIBULAR JOINT SYNDROME*†‡

JAMES B COSTEN, M D,

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Identification of the mandibular joint syndrome[1] as a symptom complex involved sorting out its qualities from the maze of known reactions of Vth nerve pain

This search began when enormous interest in otolaryngology was centered about the sphenoidal sinus and its problems Similarity in distribution of ear and vertex pain directed attention to the temporo-mandibular joint

The otolaryngologist, once interested, found many such cases because of the location of symptoms The neurosurgeon welcomed proof of such a secondary neuralgia, to explain the origin of pain reactions which were clearly not tic douloureux

The sphenoidal sinus has not been declassified as unimportant Its position of interest was simply scaled down to a secondary place by increased knowledge of allergy, nasal physiology and antibiotics

Otalgia, vertex pain, glossodynia,[2] and varieties of trismus[3] which activate the mechanism, are clearly established in diagnosis of this symptom complex

A majority of dental groups showed marked enthusiasm for this syndrome, some parts of which had appeared years ago in the dental literature It was refused by others because of disagreement with the anatomical reasoning, or because of misunderstanding of the purport and meaning of the study

There is general acceptance, however, of the origins of painful reflexes as follows *1* Abnormal condyle movement pro-

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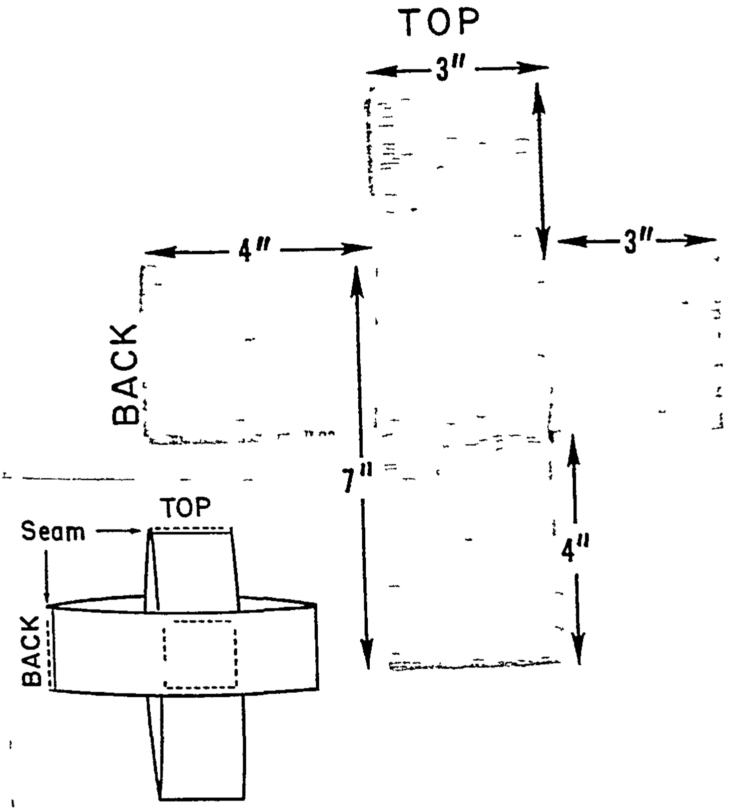

Fig 1 This type of elastic chin support is the most practical for splinting the mandible in controlling painful movement of the condyle Change from the condyle s habitual rest position is made by interposing a small cork disc between teeth opposite the painful side or bilaterally if both sides are affected

The size illustrated may be used for the average head adding ½-inch to both vertical and horizontal loops for large and using ½-inch less for smaller size ranges The supports are best produced in hospital linen rooms The material is 3-inch Natural Color Elastic Style No 3746 produced by United Elastic Corp Stuart Division Stuart Virginia

ducing sensory irritation of branches of the auriculotemporal nerve which distribute to the capsule of the joint, *2* Direct trauma to the chorda tympani[4] nerve which passes along the medial wall of the glenoid fossa, *3* and direct trauma to the retrocondylar pad,[5] known to contain sensory elements In addition to pain in these distributions, reflex pain occurs in the lingual nerve with typical glossodynia Once pain is initiated, reflex contraction of the masseter group of muscles perpetuates the trismus cycle by producing further impingement Much confusion could be avoided in correct evaluation of cases suspected of mandibular joint involvement, if the following simple classification were kept in mind, the groups overlap in many cases

The commonest source of diagnostic error is a hidden cause of sensory stimulation which is unrecognized, or a conversion neurosis case who clings to the original symptoms, refusing to admit improvement after treatment, dental or direct, has been applied The common error is to repeat treatment on the basis of positive local findings, when no improvement has been gained

CLASS I

Temporary, with otalgia and trismus effects, simple origin

1 Ulcerated teeth
2 Excessive yawn and condyle subluxation
3 Stretch of jaws under anesthesia
4 Blow on chin
5 Gripping of jaw during extreme pain
6 Parotitis, early parotid tumors
7 Furuncle or cellulitis of external ear canal
8 Quinzy
9 Injection of local anesthesia preceding dental treatment
10 Tetanus

Treatment of diseases of the temporomandibular joint, embraces everything from removal of a single source of trismus to surgical attack upon the joint itself If an accidental movement of the lower jaw, such as a blow to the jaw or a yawn, produces enough irritation within the joint, trismus and otalgia ensue The treatment is external elastic splinting, local heat and sedative drugs If the origin is an abscessed tooth or infection of the ear canal, removal of these sources is the solution

Overclosure of jaws with compression of eustachian tubes proved to be the only factor in deafness This was a subjective reaction of the patient and not substantiated by audiometric tests *The responsibility of the otologist is to oppose strongly any advice that promises that change of occlusion will benefit hearing*

CLASS II

Semi-permanent, recurrent, with pain effects and structural changes

1 Fracture of the jaw

2 Intermittent trismus from third molar impaction

3 Abnormal joint relations in development of asymmetric jaws

4 Erosion of condyle, meniscus, and tubercle, as a malocclusion effect

5 Sharing general osteoporosis

If the joint changes are secondary to long standing malocclusion and improper action of the condyle, irreversible changes in the meniscus, cartilage and bone structures of the joint occur These tissues cannot be improved, but restoration of balanced occlusion usually removes the source of stress and damage, so that pain and trismus are relieved.

So many cases of this group improve on splinting of the jaw, concurrent with injection of the joint with hydrocortisone, that restoration of occlusion becomes optional Interruption of the trismus cycle thus produces such comfort that no other treatment is necessary, unless grossly bad action of the condyle continues the irritative reflex and a pain sequence again ensues

Examples selected from this class, in which occlusal restoration has failed, or succeeded temporarily, respond to resection of the meniscus and retrocondylar pad The meniscus is usually found to be deformed, rough with dense adhesions, or impacted upon exotoses of the condylar head The retrocondylar pad, bearing sensory elements, is resected along with the meniscus Pain is relieved, but excursion of the condyle is neither restricted nor improved by the procedure

CLASS III

Semi-permanent, recurrent, with or without joint pathology

1 Bonafide pain effects relieved by occlusal restoration, but retained by patient as a conversion neurosis

2 Hysterical trismus with no joint changes

3 Pain effects, tiring of jaws, inability to tolerate dentures, based on masseter tremor

During the study of a group of cases unimproved after dentistry, masseter muscle tremor,[6] an obscure muscle reaction with psychogenic implications, was identified as important in the etiology of these unimproved cases Ordinarily, tremor has been associated with fear, shock, and neurologic changes Apart from these conditions, it had usually been unnoticed when the mandibular joint syndrome was studied The pathogenesis is not clear, neurological examination being negative

Since emotional overlay is a large factor in this condition, psychotherapy appears to hold promise in treatment Meanwhile, in spite of the failure of treatments directed to jaw structures, the patients, without exception, are relieved by passive support, simple elastic splinting of the jaw and masseter muscle group Short half-hour periods are more effective and more restful than longer ones A few have shown improvement on tranquilizing drugs, small doses being given along with other measures

CLASS IV

Permanent, developing ankylosis

1 Arthritis pain effects, subsiding as ankylosis increases

2 Fibrosis after fracture of head of condyle or tympanic plate

3 Fibrosis and osteitis after mastoiditis, a delayed effect of one year or more

4 Foreign body, as bullet injury

5 Fibrosis of internal pterygoid or masseter fascia after dental anesthesia (injection), and after parotid abscess

When excursion is restricted, partially or completely, as in ankylosis, amputation of the condyle is done All fibrous scarring about the joint and coronoid process is resected When matted and firm, removal of the coronoid process is sometimes necessary before free movement of the lower jaw is obtained When a partial or limited condylar resection is anticipated, the trouble-free endaural incision is used to expose the joint Incision anterior to the auricle, and along the zygoma may be readily used for more extensive exposure of the ramus

Unnecessary surgery on one or both joints has converted some patients belonging to the neurosis group, Class III, into mutilations of Class IV

SUMMARY

It is not necessary to revamp our reasoning as to why the mandibular joint syndrome occurs The findings are mainly objective and obvious

It is extremely important to apply direct measures to the joint action, such as elastic splinting of the jaw and injection of steroid substances These should be used routinely, over long periods, even in the presence of suspected neuroses

Four general categories have been mentioned In all groups the complex interaction of neuromuscular cycles requires the use of measures which remove the source of trouble, and still leave jaw function

Relief of pain is primary in all treatment, but as in no other joint in the body, further ankylosis must not be implemented in the course of treatment

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TUMORS OF THE NASOPHARYNX*

Case Reports

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Tumors of the nasopharynx may be classified as benign or malignant The benign variety is occasionally malignant in effect by reason of position, as will be illustrated The most frequent benign lesion is the juvenile nasofibroma, others are neurofibromas, lipomas, chondromas, and teratomas

Examples of the most frequently found malignant tumors are *1.* Squamous cell carcinoma, *2* anaplastic carcinoma; *3* lympho-epithelioma, *4* salivary gland tumor; *5* lymphoma, and *6* plasmocytoma

Malignant growths of the nasopharynx are frequently so anaplastic that classification is often a matter of opinion[1] One radiotherapist[2] classifies all malignant tumors of the nasopharynx as those of limited radiosensitivity and those of marked radiosensitivity The first of these is squamous cell carcinoma, and the second is the anaplastic variety, which includes all the others

It is also interesting to note that the nasopharynx, being as inaccessible as it is, and the primary tumor frequently being only a small non-ulcerated elevation of the mucosa, not only the clinician during life, but also the pathologist at autopsy has difficulty in identifying the primary site of the tumor

It is not surprising then to find that in three series of cases (Gotfredsen,[3] Simmons and Ariel,[4] and McWhirter[5]) the average elapsed time between the first visit to the physician and the discovery of the primary site was ten months This regrettable lapse of time constitutes the chief reason for writing this paper We hope that by focussing attention to tumors in

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this area we will be able to alert at least some members of the medical profession who will be able to make a diagnosis before the condition has progressed to the stage of cervical node metastasis

The age of the malignant cases varies from 16 to 80 years One author (Schindler,[6] et al) reported a teratoma in the nasopharynx of a newborn, which was removed successfully when the patient was only 18 hours old Juvenile nasofibromas occur usually a few years prior to and during puberty They may or may not tend to regress in the mid-twenties The preponderance of malignant cases is in males by a ratio of almost 2 to 1 There is a much higher incidence of malignancy among the Orientals, especially those from the southern provinces of China[7] This racial predisposition is present among the Chinese, whether they are in their native country or have been transplanted to other lands The statement has been made that if one passes in the street a cross-eyed Chinese with a swelling in his neck the diagnosis of a carcinoma of the nasopharynx can practically be made in passing

SYMPTOMS

Benign tumors present obstructive symptoms locally in the nasopharynx, producing either nasal obstruction or eustachian tube obstruction, or both

Malignant tumors present a variety of symptoms which may lead the patient to a general practitioner, a neurologist, an ophthalmologist, an otolaryngologist, or a dentist These symptoms may be conveniently grouped into three categories *1* Those attributable to the primary tumor, *2* those which result from direct extension of the tumor outside the nasopharynx, *3* those which result after metastasis to the regional lymph nodes occurs

1 Findings due to the primary tumor[8]

These consist of a variety of commonplace complaints, and this is one reason that a diagnosis is not made earlier These are in the order of frequency—nasal obstruction, deafness unusual post-nasal discharge, which is sometimes blood-tinged, and occasionally tinnitus

2 Findings due to extension outside the nasopharynx[5]

The motor nerves of the eyes are most frequently affected The abducens nerve is the most vulnerable, and diplopia and a convergent squint are frequent findings The Vth, IIIrd, and IVth cranial nerves, in that order of frequency, are also affected and produce visual disturbances, ocular paralysis, facial pain, headache, and trismus When the tumor encroaches on the juglar foramen the IXth, Xth, XIth and XIIth cranial nerves, and the cervical sympathetic trunk become involved, producing Horner's syndrome and paralysis of the tongue and vocal cord With such a diversity of nerves involved it is small wonder that the patient becomes confused as to whom to seek in his dilemma Even the physician, or dentist whom he seeks, is frequently confused, and many sound teeth are extracted and many unnecessary operations performed in a vain effort to remedy his unresolved complaints

The tumor may extend up the eustachian tube and produce tinnitus, deafness and serous otitis In some cases the middle ear has been invaded and material for biopsy has been taken from the external auditory canal

3 Findings after extension to regional lymph nodes[5]

The nodes most frequently involved are those high up in the posterior cervical chain They are usually soft and quite large The enlargement is usually more advanced on one side than on the other

DIAGNOSIS

Examination of the nasopharynx may be accomplished by inspection, palpation, X-ray examination, or any combination of the three

Inspection may be done by using a nasopharyngoscope, a Yankauer's speculum or a postnasal mirror By using a soft rubber catheter, the two ends of which are threaded through the nostrils and the loop drawn up against the columella as the ends are drawn through the mouth, the soft palate may be elevated A postnasal mirror may be used after elevation of the soft palate by the catheter Local anesthesia in the form of a spray or nasal packs may be used to facilitate these procedures

Palpation may be accomplished by inserting a finger into the nasopharynx under either local or general anesthesia Occasionally it is necessary to split the uvula and soft palate while the patient is under anesthesia to facilitate inspection

Roentgenograms of the region are often quite helpful Lateral views and occipto-mental views are particularly useful The lateral views may be taken with the head erect or with the patient lying on his back and his head over the end of the table In the latter position, iodized oil is instilled into the nasopharynx and may show a filling defect The occipto-mental view is of particular value in showing erosion of bone at the base of the skull

Cytological examination of nasal and choanal washings is a diagnostic aid of some value

Diagnosis is confirmed by biopsy Tissue may be difficult to obtain, and occasionally the process is accomplished only by blind biopsy, in which the biting forceps are introduced along the floor of the nose

PROGNOSIS

If the tumor is malignant and of the anaplastic, radiosensitive variety, and is of limited scope, the outlook is fairly promising if irradiation is begun promptly If the tumor is a squamous cell carcinoma of limited radiosensitivity the prognosis is not so good

If bone erosion has occurred the mortality is almost 100 per cent

If the tumor is a juvenile nasofibroma which fails to respond to the usual remedies, it may extend intracranially and produce fatal results

TREATMENT

Irradiation of the radiosensitive tumors of the nasopharynx is the treatment of choice

Those tumors of limited radiosensitivity, *i e*, the squamous cell carcinomas and the juvenile nasofibromas usually require a combination of X-ray therapy followed by surgical extirpation The juvenile nasofibromas should also be treated with testosterone

The strictly benign tumors are removed surgically

In the author's opinion, the trans-palatine procedure offers the best approach to this area

CASE REPORTS

The first three case reports have to do with juvenile nasofibromas and show how greatly they can vary in degree of involvement

Case 1 The first is that of L H, whose diagnosis was made in 1953 at the age of nine years Attention was first attracted to his condition by a recurring nosebleed During the next five years there were three attempts at surgical removal and four courses of X ray therapy At his last visit, in November, 1958, the tumor had almost completely disappeared, and he was playing football and leading a normal life for his age

This case is presented to illustrate what may be expected of a nasofibroma which responds to the usual therapy

Case 2 The second case is that of T K, whose nasofibroma was discovered during the course of a routine adenoidectomy in September, 1943, at nine years of age It was incompletely removed at this time and recurred The patient's family became converted to the Christian Science faith and refused to allow further medical or surgical interference The tumor continued to grow for a number of years, and invaded the nasal cavity and the right antrum Meanwhile the patient had joined the Armed Forces and was stationed in Tokyo In October, 1955, at the Tokyo General Hospital he had a radical extirpation of the tumor There had meanwhile developed a considerable facial deformity The tumor completely disappeared and the facial deformity is the only permanent defect that he has

This case shows what comes to pass when a nasofibroma is neglected for a number of years

Case 3 The third case is that of W S, whose nasofibroma was first discovered in October, 1957 when he was 14 years old He was given a course of X-ray therapy, and an attempt at surgical removal was made in January, 1958 This was only partially successful, and the tumor developed rather rapidly In June, 1958 another attempt at removal was made including splitting the uvula and soft palate to facilitate a more adequate exposure The left external carotid had to be tied off at this time to control hemorrhage

Just before operation a swelling had appeared in the left temporal area This increased in size after operation The tumor in the nasopharynx again increased rapidly in size in spite of Roentgen therapy and testosterone After considerable investigation, including angiograms it was decided to try to remove the tumor surgically, including the extension to the left temporal area This was done in September, 1958 Extensive bleeding was encountered and it required eight hours to perform the operation, and 19 pints of blood were used The right external carotid artery was tied off at this operation, and the patient had a smooth post operative course A few weeks later he was readmitted to the hospital with findings indicative of an intracranial spread Further neurosurgery is contemplated at this time

This case illustrates a rapid growing nasofibroma which failed to respond to X ray therapy, surgery, and testosterone It has become malignant by position, extended intracranially, and undoubtedly will terminate fatally

The second three cases are illustrative of malignant lesions of the nasopharynx

Case 1 The first of these is that of W M, a 54 year old white male who was referred by a neurologist He was first seen on October 15, 1957 Two weeks before this he had noted double vision Approximately a year before he had noticed tinnitus followed by deafness in his right ear

Examination revealed a convergent squint of the right eye, the right drum was off color and full, and the right submaxillary gland was enlarged Examination of the nasopharynx revealed a granulomatous lesion in the mouth of the right eustachian tube An audiogram showed a 34 per cent loss in the right ear and a 12 per cent loss in the left The loss was greater in the high tones A caloric test was done and showed no response to stimulation of the right ear and a normal response of the left Biopsy was done under general anesthesia on the following day, and the tissue was reported to show transitional cell carcinoma

Irradiation was started, and aside from the usual skin and mucus membrane reactions his course has been uneventful The reaction has produced a blockage of his left eustachian tube, so that he now has a bilateral deafness necessitating his wearing a hearing aid His VIth nerve palsy has cleared up and the cervical node has disappeared His prognosis must remain guarded for several more years

This case is presented to show the usual intracranial extension which involved the VIth nerve eustachian tube, and middle ear This is a radiosensitive tumor which has not produced bone erosion, and so the outlook is somewhat encouraging

Case 2 The second of the malignant cases is that of G S, a white male 55 years old, who was first seen on April 23, 1955 His complaint at this time was a feeling of fullness of the ears

Examination revealed that both drums were slightly retracted The eustachian tubes were inflated, and both were obstructed We saw him again in April, once in May, and three times in June with this same complaint His tubes were inflated on each occasion He was referred to an internist in July for a complete examination which was essentially negative He complained of pain in the cheek, and X ray films revealed a carious tooth root, which was extracted by his dentist Pain in the cheek persisted after the extraction, and he was admitted to Baker Hospital, where a roentgenogram on July 30 1955, revealed a large mass in the nasopharynx This was examined by biopsy and was reported as lymphosarcoma X-ray therapy was begun and for a while the patient improved, however, distant metastases occurred and in spite of further X ray treatments and the use of nitrogen mustard the patient died in February, 1956

This case is illustrative of the difficulty in arriving at a correct diagnosis and the ease with which one may be misled by the commonplace complaints of tinnitus, partial deafness and the finding of dental caries as a possible cause of pain in the face area

Case 3 The third case is that of E L, a 56-year-old white male who was first seen May 26, 1955 He complained of difficulty in swallowing, difficulty in raising his right shoulder, and hoarseness, all of about six weeks' duration

Examination revealed evidence of involvement of cranial nerves IX, X, and XI (right) with partial paralysis of the right side of the soft palate loss of sternomastoid and trapezius function, and paralysis of the right vocal cord with the right cord in the mid line Inspection of the naso pharynx was essentially negative

Biopsy of the nasopharynx was done on the following day under general anesthesia and showed epidermoid carcinoma

His local lesion was controlled with X-ray therapy and the use of radium applicators, but he died of liver metastasis on April 9 1957

The third malignant case shows what nerves may be involved when the tumor involves the region of the jugular foramen It also shows the difficulty of visualizing the tumor, even when one is sure it is in the nasopharynx

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SOME RELATIONSHIPS BETWEEN PITCH DISCRIMINATION AND SPEECH DEVELOPMENT*

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INTRODUCTION

Clinicians dealing with hearing-handicapped children have long been aware that such children are prone to have difficulty in achieving normal speech development. The explanation given for this observation has been that because of the hearing impairment, the child is unable to hear and differentiate the many variations in sound which make up human speech. Without a subjective awareness of these variations, the child is unable to imitate and thus produce accurately the complex combinations of sound which we call human speech; however, we are all aware that abnormal speech development and articulation problems are not limited to the hearing-handicapped child alone. In any active clinical practice or hearing and speech center many children with articulation difficulty are seen in whom no hearing impairment is evident. In attempting to postulate why these children should have such difficulty, the possibility of an alteration in the function of pitch discrimination was considered. It would seem logical that an inability to appreciate fine changes in pitch might be a factor in preventing a child from subjectively experiencing the difference between certain sounds. The inability to be aware of such differences would then limit the ability of the child to imitate accurately and thus produce human speech.

With this reasoning as a background, an attempt has been made on the basis of clinical testing to determine whether or not a significant relationship exists between the ability

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to discriminate between pitches (frequencies) and the development of normal speech

REVIEW OF THE LITERATURE

Pitch is one of the attributes of a tone as heard by a listener and is, therefore, a subjective auditory experience[11] Pitch is usually correlated with the frequency of sound waves as this correlation is so obvious An individual normally will describe the pitch of a tone as low when the sound wave-length is long and will describe the pitch as progressively higher when the sound wave-length becomes progressively shorter Thus, we have the tendency to correlate pitch with frequency as a direct relationship

Numerous investigators have shown, however, that pitch is also a function of intensity[12, 15, 19, 21] and duration[14, 24] The variation of pitch with intensity is very small Pollack[15] showed that the ability to discriminate between pitches improves at high intensity and becomes poorer as the intensity lessens He also showed that as threshold is approached, an "atonal interval" is encountered where differential pitch discrimination is absent Morgan, Garner, and Galambos[13] showed that pitch tends to drop with increasing intensity if the frequency is below 1000 cycles, but that it tends to rise if the frequency is above 4000 cycles At 2000 cycles, there is very little variation with intensity change Harris[10] emphasized the importance of the method used in making such determinations, and the variations which occur with the method employed The relationship of duration to pitch is more difficult to quantitate Turnbull[24] demonstrated that if tones are very short in duration (less than six msec) it is impossible for most subjects to associate pitch with them As the duration increases up to 12 to 15 msec , pitch association is possible Once the duration exceeds this threshold, however, the pitch experience becomes only subjectively better established in the subject's consciousness As can be seen from the preceding, although both intensity and duration are related to pitch, the major relationship is between frequency and pitch

Shower and Biddulph[18] showed that for frequencies below

1000 cycles the just-noticeable difference in the frequency of two pure tones is about three cycles Above 1000 cycles the number of cycles that a tone must change in order to sound noticeably different is proportional to the frequency of the tone As the frequency of the tone increases, the size of the just-noticeable difference increases proportionately Somewhat larger differences in frequency are necessary if the tone is less than 50 decibels above the hearing threshold Boring[3] reviewed the procedures of previous investigators and suggested reasons for discrepancies in the DL's for frequency obtained Rosenblith and Stevens[16] reported smaller values than Shower and Biddulph, but showed that the DL's obtained varied with the procedure used

Wyatt[26] and Seashore[17] have both demonstrated that there is a wide variation among normal individuals in the ability to discriminate between pitches Seashore[17] felt that this is essentially an innate ability and that such a deficiency could not be appreciably improved by practice and learning Wyatt,[26] however, showed examples where marked improvements had been achieved in both children and adults after training in pitch perception and discrimination Galambos[7] expressed the feeling that the pitch experience in man results from a combination of an inborn ability to analyze the difference between tonal frequency and the acquired skill in doing so It is a function for which a neurological basis is provided, but each individual may use and cultivate it or not as he will

Although attempts at localization of the function of pitch perception have yielded much information, many aspects of this question remain unanswered Steinberg[20], and Bekesy and Rosenblith[2] felt that a sharply localized region of the basilar membrane was specifically excited by each frequency Tasaki[22 23] on the basis of information gained from stimulating single auditory nerve fibers in a guinea pig, has provided data regarding the response of the auditory nerve fibers Some respond only to low tones, some to low and middle range tones, and others to tones of all frequencies When the high frequency limit of a fiber is reached, the sensitivity of the fiber drops abruptly and provides a characteristic cutoff point for the specific fiber Tasaki[22 23] reasoned that this cutoff point was perhaps analogous to the cutoff in mechanical motion of the basilar membrane reported by Bekesy[1] after observation of cochlear models This data would tend to support the contention that low frequencies arouse activity over most of the basilar membrane and its related nerve endings, while progressively higher frequencies produce involvement of progressively smaller areas Microelectrode studies at the level of the cochlear nucleus by Galambos, Rose and Hughes[3] have shown that a place on the basilar membrane is directly related to a place in the cochlear nucleus Davis[4] stated that each second-order neuron is "tuned" to a particular frequency Less acoustic energy is required at this frequency than at any other to set up impulses With increasing intensity this "tuning" becomes less sharp, and the neuron responds to an increasingly broader band of frequencies Studies at cortical levels have been mainly by extirpation Evarts[6] reported that the removal of auditory cortex in monkeys producing degeneration of over 90 per cent of the medial geniculates failed to abolish pitch perception Similar studies by Girden[9] on the dog, and by Diamond and Neff[5] on the cat have been reported These studies would suggest that tone discrimination is still possible when the cortical termination of the auditory pathway is severely damaged

EXPERIMENTAL DESIGN

This study was undertaken in an attempt to determine on the basis of clinical testing whether or not in children a significant relationship exists between impaired pitch discrimination and defective speech development

Subjects

Children between the ages of nine and 14 years were selected Although younger children would have been desirable from the standpoint of an increased incidence of impaired speech development, they were excluded because an exploratory study revealed marked difficulty in their accurate comprehension and performance of the experimental procedures Only children who showed at least normal intelligence levels as determined by one of the following tests Stanford-Binet, Form L or M, WISC, the Columbia Mental Maturity Scale, and the International Leiter Scale were used Multiple tests were used so that the hard-of-hearing children would not be penalized by a pure verbal test The subjects were then divided into three categories *1* children with normal hearing and normal speech, *2* children with normal hearing and articulation defects severe enough to require speech therapy, and *3* children with impaired hearing and impaired speech development

Equipment

An Audivox audiometer, Model 7B, was used for pure tone testing A Panacoustic speech audiometer, Model SA-101, was used for speech testing A General Radio beat frequency oscillator, Model 1304-A, was used to deliver the test tones for pitch discrimination This oscillator allowed changes in frequency to be made in one cycle increments A Grason Stadler attenuator, Model 350, was used in order that the frequencies might be presented at 50 db above threshold The test frequencies were delivered to the subject's ears through the PDR 10 earphones

Materials

The C I D recordings using Spondee (W-1) and PB (W-22) words were used for speech audiometry Basic articulation tests using pictures, words, and sentences for procuring an articulatory error profile for each child were used

Procedures

Pure tone audiometry, speech audiometry, and basic articulation testing was then administered to each child These test procedures were carried out in order that each child might be placed in the proper category Frenquency (pitch) discrimination was then carried out in the following manner The three speech frequencies, 500, 1000, and 2000 cycles, were used for testing The subject was instructed in the techniques of the testing, and varying changes in frequency were demonstrated to him A practice period was permitted to insure complete familiarity with the test materials and procedures When the examiner was satisfied that the subject understood the test procedure, actual testing was begun With each of the three tones, 500, 1000, and 2000 cycles, as a reference point at an intensity 50 db above threshold, the just-noticeable difference in pitch, both ascending and descending, was then determined Five readings were obtained for each value, and the average determined This procedure was carried out for each ear individually. Originally, the value was also determined for both ears together, however, since analysis of initial data revealed no essential change for this value, it was not obtained in later testing, and is not included in this experiment The typical response sheet is shown in Fig 1

Name Date
Age

RIGHT EAR.

	500		1000		2000	
	D	A	D	A	D	A
	1	1	1	1	1	1
	2	2	2	2	2	2
	3	3	3	3	3	3
	4	4	4	4	4	4
	5	5	5	5	5	5
Average						

LEFT EAR.

	500		1000		2000	
	D	A	D	A	D	A
	1	1	1	1	1	1
	2	2	2	2	2	2
	3	3	3	3	3	3
	4	4	4	4	4	4
	5	5	5	5	5	5
Average						

D—Descending
A—Ascending

FIGURE 1

ANALYSIS AND DISCUSSION OF DATA

This experiment was designed to compare the performance of normal, articulation defective, and impaired hearing children on frequency DL's at 500, 1000, and 2000 cycles These frequencies were selected because of their contribution to speech intelligibility In evaluating these performances, analysis of variance ("F" values)* provided a good method for indicating significant differences between frequency, side and the International Leiter Scale were used Multiple tests were used so that the hard-of-hearing children would not be penalized by a pure verbal test The subjects were then divided into three categories *1* children with normal hearing and normal speech, *2* children with normal hearing and articulation defects severe enough to require speech therapy, and *3* children with impaired hearing and impaired speech development

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* F value The F value is a statistic to determine the variance ratio between the performance of individuals in a group and the performance of the group

Equipment

An Audivox audiometer, Model 7B, was used for pure tone testing A Panacoustic speech audiometer, Model SA-101, was used for speech testing A General Radio beat frequency oscillator, Model 1304-A, was used to deliver the test tones for pitch discrimination This oscillator allowed changes in frequency to be made in one cycle increments A Grason Stadler attenuator, Model 350, was used in order that the frequencies might be presented at 50 db above threshold The test frequencies were delivered to the subject's ears through the PDR 10 earphones

Materials

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Procedures

Pure tone audiometry, speech audiometry, and basic articulation testing was then administered to each child These test procedures were carried out in order that each child might be placed in the proper category Frenquency (pitch) discrimination was then carried out in the following manner The three speech frequencies, 500, 1000, and 2000 cycles, were used for testing The subject was instructed in the techniques of the testing, and varying changes in frequency were demonstrated to him A practice period was permitted to insure complete familiarity with the test materials and procedures When the examiner was satisfied that the subject understood the test procedure, actual testing was begun With each of the three tones, 500, 1000, and 2000 cycles, as a reference point at an intensity 50 db above threshold, the just-noticeable difference in pitch, both ascending and descending, was then determined. Five readings were obtained for each value, and the average determined. This procedure was carried out for each ear individually. Originally, the value was also determined for both ears together; however, since analysis of initial data revealed no essential change for this value, it was not obtained in later testing, and is not included in this experiment. The typical response sheet is shown in Fig. 1.

Name Date
Age

RIGHT EAR

D 500	A	D 1000	A	D 2000	A
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
Average					

LEFT EAR

D 500	A	D 1000	A	D 2000	A
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
Average					

D—Descending
A—Ascending

FIGURE 1

ANALYSIS AND DISCUSSION OF DATA

This experiment was designed to compare the performance of normal, articulation defective, and impaired hearing children on frequency DL's at 500, 1000, and 2000 cycles. These frequencies were selected because of their contribution to speech intelligibility. In evaluating these performances, analysis of variance ("F" values)* provided a good method for indicating significant differences between frequency, side

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* F value. The F value is a statistic to determine the variance ratio between the performance of individuals in a group and the performance of the group.

TABLE I

Raw Scores for Eleven Normal Subjects on DL, Both Ascending and Descending for Frequency at 500, 1,000, and 2,000 Cycles for Right and Left Ears

Subject	500 Cycles				1,000 Cycles				2,000 Cycles			
	Ascending		Descending		Ascending		Descending		Ascending		Descending	
	R	L	R	L	R	L	R	L	R	L	R	L
(1) B S	3	3	3	4	5	5	5	6	7	8	8	9
(2) A M	4	7	4	7	7	7	4	6	5	8	8	[illegible]
(3) R C	5	6	7	7	5	5	4	7	7	6	5	[illegible]
(4) J B	6	6	6	10	7	8	4	9	9	10	9	9
(5) N C	8	7	6	7	7	8	8	7	5	7	4	[illegible]
(6) P S	7	8	7	8	7	8	7	7	9	9	9	9
(7) D S	7	7	10	10	8	8	11	12	8	8	10	9
(8) D H	8	7	7	8	9	8	7	6	10	9	8	9
(9) F R	6	8	8	8	8	7	9	8	10	10	12	19
(10) D S	5	6	5	7	8	8	8	8	11	11	11	19
(11) W S	8	9	9	10	10	9	10	9	12	12	13	19

R = Right Ear L = Left Ear

TABLE II

Raw Scores for Eleven Defective Articulation Subjects on DL, Both Ascending and Descending, for Frequency at 500, 1,000, and 2,000 Cycles for Right and Left Ears

Subject	500 Cycles				1 000 Cycles				2 000 Cycles			
	Ascending		Descending		Ascending		Descending		Ascending		Descending	
	R	L	R	L	R	L	R	L	R	L	R	L
(1) G D	15	19	24	29	48	39	136	148	100	104	180	232
(2) C T	10	17	16	38	17	17	19	18	42	36	110	85
(3) F L	12	13	9	8	13	13	18	14	18	19	31	20
(4) D K	15	16	25	30	18	20	28	30	36	44	70	69
(5) L R	7	9	7	7	9	15	9	14	15	15	19	20
(6) D T	13	8	18	14	14	17	18	21	55	45	60	55
(7) B D	7	17	8	8	9	10	9	9	17	13	15	18
(8) J R	8	8	9	10	8	9	10	12	10	11	14	17
(9) R J	10	9	9	8	15	14	13	12	16	17	15	16
(10) C B	12	10	12	9	12	12	11	11	14	15	12	14
(11) E P	12	15	14	15	18	19	20	21	21	22	24	25

R = Right Ear L = Left Ear

(left or right), and direction (ascending or descending) The study also permitted the calculation of "t" values* for analysis of the data

Tables I, II, and III present the raw scores in frequencies for 11 normal, 11 defective articulation, and 11 impaired hearing subjects on DL for frequency at 500, 1000, and 2000 cycles Tables IV, V, and VI indicate the mean and the variance values for 11 normal, 11 defective articulation, and 11 impaired hearing subjects on DL for frequency at 500,

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*"t value The t value is a statistic which indicates whether or not differences between the means of groups are significant

1000, and 2000 cycles Examination of the Tables reveals that performance for the normals shows the least variation among the subjects The Tables also reveal the greatest variation for the impaired hearing subjects with a moderate variability for the defective articulation subjects At 1000 and 2000 cycles both the defective articulation and the impaired hearing subjects present a wider variation with the greater variation occurring at 2000 cycles Further inspection of these Tables exhibits an increase in the mean DL's from low to high frequency

TABLE III

Raw Scores for Eleven Impaired Hearing Subjects on DL Both Ascending and Descending for Frequency at 500 1 000, and 2 000 Cycles for Right and Left Ears

Subject	500 Cycles				1 000 Cycles				2 000 Cycles			
	Ascending		Descending		Ascending		Descending		Ascending		Descending	
	R	L	R	L	R	L	R	L	R	L	R	L
(1) M A	108	116	106	114	108	118	110	114	212	242	210	222
(2) E D	54	54	58	58	108	106	110	110	144	136	130	120
(3) B P	152	104	114	104	152	118	150	116	498	484	500	456
(4) S S	112	116	112	114	124	122	124	120	244	232	236	232
(5) R L	59	74	69	66	106	114	106	116	236	212	240	208
(6) R D	60	48	58	46	78	66	84	68	110	110	108	112
(7) C B	84	36	84	36	102	48	114	48	184	52	184	52
(8) B R	49	46	47	44	44	48	43	44	50	60	48	54
(9) D R	52	57	52	58	110	102	108	96	110	106	112	108
(10) S B	52	52	43	54	126	120	122	122	254	250	252	250
(11) J S	28	22	17	20	20	34	22	30	134	141	200	300

R = Right Ear L = Left Ear

Tables VII, VIII, and IX present the analysis of variance with respect to frequency, side and direction for the normal, articulation defective, and impaired hearing subjects Table VII reveals an "F" value of 12 64 for performance on frequency DL's in the normal subjects This reveals a significant difference between the performance at the different frequencies since the "F" value at the 1 per cent level of confidence is 4 78 A value of 12 64 is significant beyond the 1 per cent level and consequently, permits the rejection of the null hypothesis* Examination of the Table reveals also that the differences between the means with respect to side

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*Null hypothesis The null hypothesis states that differences in performance among individuals or groups may be due to chance and consequently are not real or significant differences

TABLE IV

Mean and Variance Values for Eleven Normal Subjects on DL, Both Ascending and Descending, for Frequency at 500, 1,000, and 2,000 Cycles for Right and Left Ears

	500 Cycles				1 000 Cycles				2 000 Cycles			
	Ascending		Descending		Ascending		Descending		Ascending		Descending	
	R	L	R	L	R	L	R	L	R	L	R	L
X	6 09	6 73	6 55	7 82	7 36	7 36	7 00	7 73	8 45	8 91	8 82	9 18
σ^2	2 89	2 42	4 27	3 16	2 25	1 65	6 20	3 22	5 27	3 09	7 36	4 76

R = Right Ear L = Left Ear

TABLE V

Mean and Variance Values for Eleven Defective Articulation Subjects on DL, Both Ascending and Descending, for Frequency at 500, 1,000, and 2,000 Cycles for Right and Left Ears

	500 Cycles				1 000 Cycles				2 000 Cycles			
	Ascending		Descending		Ascending		Descending		Ascending		Descending	
	R	L	R	L	R	L	R	L	R	L	R	L
X	11 00	12 82	13 73	16 00	16 45	16 82	26 45	28 18	31 27	31 00	50 00	51 91
σ^2	8 20	17 16	40 42	121 20	122 27	66 36	1,354 27	1,615 56	715 82	737 60	2,818 80	4,168 49

R = Right Ear L = Left Ear

TABLE VI

Mean and Variance Values for Eleven Impaired Hearing Subjects on DL, Both Ascending and Descending, for Frequency at 500, 1,000, and 2,000 Cycles for Right and Left Ears

	500 Cycles				1 000 Cycles				2 000 Cycles			
	Ascending		Descending		Ascending		Descending		Ascending		Descending	
	R	L	R	L	R	L	R	L	R	L	R	L
X	73 64	65 91	69 09	64 91	98 00	90 55	99 36	89 45	197 82	184 09	201 82	192 18
σ^2	1 331 25	1 048 89	986 29	1 021 09	1 420 00	1 170 47	1 364 05	1 224 87	14 149 16	14 932 09	14 013 16	14 476 36

R = Right Ear L = Left Ear

TABLE VII

Analysis of Variance for Eleven Normal Subjects for Frequency, Side, and Direction on DL at 500, 1,000, and 2,000 Cycles for Right and Left Ears

Source	SS	df	MS	F
Frequency	98.11	2	49.05	12.64*
Side	10.94	1	10.94	2.82
Direction	4.36	1	4.36	1.12
F × S	2.38	2	1.19	.31
F × D	3.32	2	1.66	.43
S × D	1.48	1	1.48	.38
F × S × D	1.11	2	.55	.14
Within	465.64	120	3.88	
Total	587.33	131		

*	.01	.05
$F_{120,2}$	4.78	3.07
$F_{120,1}$	6.84	3.92

TABLE VIII

Analysis of Variance for Eleven Defective Articulation Subjects for Frequency, Side, and Direction on DL at 500, 1,000, and 2,000 Cycles for Right and Left Ears

Source	SS	df	MS	F
Frequency	17,635.56	2	8,817.78	8.98*
Side	56.03	1	56.03	
Direction	4,103.76	1	4,103.76	4.18
F × S	9.38	2	4.69	
F × D	1,567.74	2	783.87	
S × D	14.67	1	14.67	
F × S × D	4.11	2	2.05	
Within	117,861.64	120	982.18	
Total	141,252.88	131		

*	.01	.05
$F_{120,2}$	4.78	3.07
$F_{120,1}$	6.84	3.92

and direction were not significant. Only on frequency was the DL performance statistically significant.

Table VIII reveals an "F" value of 8.98 for the defective articulation subjects on frequency performance. Since the value of 4.78 is significant at the 1 per cent level, the obtained "F" value for frequency is significant beyond the 1 per cent level and also permits the rejection of the null hypothesis. Examination of the Table also reveals an "F" value of 4.18 for direction Since an "F" value of 3 92 is significant at the 5 per cent level, the obtained "F" value of 4 18 is statistically significant between the 1 per cent and 5 per cent levels of confidence These two "F" values indicate significant differences of performance for both frequency and direction This finding of a statistically significant difference on direction reflects inferior performance on this task when compared with the normals This inferiority may be a contributing factor to defective articulation since cues requiring precise discrimination for phonetic analysis may be lacking Examination of the Table also reveals no significant difference in performance for side

TABLE IX

Analysis of Variance for Eleven Impaired Hearing Subjects for Frequency, Side, and Direction on DL at 500, 1,000, and 2,000 Cycles for Right and Left Ears

Source	SS	df	MS	F
Frequency	386,820 42	2	193,410 21	34 57*
Side	2,539 70	1	2,539 70	45
Direction	42 61	1	42 61	
F × S	180 55	2	90 27	
F × D	443 68	2	221 84	
S × D	24 62	1	24 62	
F × S × D	73 04	2	36 52	
Within	671,377 09	120	5,594 81	
Total	1,061,501 72	131		

*	01	05
$F_{1\,5\,2}$	4 78	3 07
$F_{1\,5\,1}$	6 84	3 92

Table IX presents the "F" values for frequency, side, and direction for the impaired hearing subjects The obtained "F" value for frequency of 34 57 is significant beyond the 1 per cent level of confidence Inspection of Tables VII, VIII, and IX reveals that the impaired hearing subjects have the greatest differences on DL's for frequency Examination of Tables IV, V, and VI reveals that the defective hearing subjects also exhibit the greatest difficulty in frequency discrimination The mean values at 2000 cycles for ascending and descending performance range from 184 09 to 201 82 cycles. When compared with the normals whose performance ranged from 8.45 to 9.18 cycles, the differences are more than 20 times as great. This inability to discriminate within narrower ranges indicates that their discrimination bands are wide, which would provide a source for error. The difference in the performance of the defective articulation group while not so large as the impaired hearing group is larger than the normal group. This phenomenon is reflected in the language development of the two groups. In addition to retarded speech development the child with impaired hearing often also has a retarded language development, while the child with articulatory defects presents a retarded speech development but not a retarded language development. This point would tend to validate further the articulatory error profiles obtained on the children in these two groups. The defective hearing children consistently showed more errors than the defective articulation children, and the errors which they showed were more gross, that is, errors of distortion and substitution.

Table X presents the mean differences, degrees of freedom, and "t" values for DL for frequency at 500, 1000, and 2000 cycles for normal and defective articulation subjects. The "t" values with the exception of the performance on the descending at 1000 cycles are statistically significant. This indicates that the performances of the defective articulation subjects on every aspect except descending at 1000 cycles are inferior. These findings are consistent with the previous analysis.

Table XI presents the mean differnces, degrees of freedom, and "t" values for DL for frequency at 500, 1000, and 2000 cycles for normal and defective hearing subjects. The "t" values for very relationship are statistically significant at below the 1 per cent level of confidence. These values unequivocally indicate the inferiority of the defective hearing group on frequency DL when compared with the normal group. These findings support the previous analysis and indicate that the defective hearing subjects require a very large frequency discriminant before they can make just-noticeable difference judgments.

TABLE X

"D" and "t" Values for Eleven Normal and Eleven Defective Articulation Subjects on DL, Both Ascending and Descending, for Frequency at 500, 1,000, and 2,000 Cycles for Right and Left Ears

	500 Cycles				1000 Cycles				2 000 Cycles			
	Ascending		Descending		Ascending		Descending		Ascending		Descending	
	R	L	R	L	R	L	R	L	R	L	R	L
"D"												
$X_1 - X_2$	4 91	6 09	7 18	8 18	9 09	9 45	19 45	20 45	22 82	22 09	41 18	42 73
df	20	20	20	20	20	20	20	20	20	20	20	20
"t"												
D/C	4 89	4 57	3 56	2 43	2 70	3 80	1 75	1 69	2 82	2 69	2 57	2 19

R = Right Ear L = Left Ear 't" 01 = 2 85 "t" 02 = 2 528 't" 05 = 2 086

TABLE XI

"D" and "t" Values for Eleven Normal and Eleven Impaired Hearing Subjects on DL, Both Ascending and Descending, for Frequency at 500, 1,000, and 2,000 Cycles for Right and Left Ears

	500 Cycles				1 000 Cycles				2 000 Cycles			
	Ascending		Descending		Ascending		Descending		Ascending		Descending	
	R	L	R	L	R	L	R	L	R	L	R	L
"D"												
$X_1 - X_2$	67 55	59 18	62 55	57 09	90 64	83 18	92 36	81 73	189 36	175 18	193 00	183 00
df	20	20	20	20	20	20	20	20	20	20	20	20
"t"												
D/C	6 13	6 05	6 59	5 92	7 97	8 06	8 28	7 73	5 28	4 75	5 41	5 04

R = Right Ear L = Left Ear 't" 01 = 2 85 "t" 02 = 2 528 t" 05 = 2 086

TABLE XII

"D" and "t" Values for Eleven Impaired Hearing and Eleven Defective Articulation Subjects on DL, Both Ascending and Descending, for Frequency at 500, 1 000, and 2,000 Cycles for Right and Left Ears

	500 Cycles				1 000 Cycles				2 000 Cycles			
	Ascending		Descending		Ascending		Descending		Ascending		Descending	
	R	L	R	L	R	L	R	L	R	L	R	L
"D'												
$X_1 - X_2$	62 64	53 09	55 36	48 91	81 55	73 73	72 91	61 27	166 55	153 09	151 82	110 27
df	20	20	20	20	20	20	20	20	20	20	20	20
't"												
D/C	5 68	5 39	5 73	4 80	6 89	6 95	4 61	3 81	4 73	4 06	3 88	3 41

R = Right Ear L = Left Ear t 01 = 2 85 t 02 = 2 528 t = [illegible]

Table XII presents the mean differences, degrees of freedom, and "t" values for DL for frequency at 500, 1000, and 2000 cycles for defective articulation and impaired hearing subjects The "t" values for every relationship are statistically significant at below the 1 per cent level of confidence The values reveal that the impaired hearing subjects are unequivocally inferior to the defective articulation subjects in DL's for frequency, thus, analysis of the data shows that while the defective articulation group is inferior in performance to the normal group, it is superior to the impaired hearing group The impaired hearing group performance is markedly inferior to both of the other groups

The findings throughout the study are consistent, and after verification by statistical analysis, support the hypothesis that pitch discrimination is a factor contributing to the development of speech and language for hearing impaired children, moreover, the study suggests that pitch discrimination may be a contributory factor in the development of speech for children with articulation defects

Since it has been suggested earlier in this discussion that the functions of pitch perception and pitch discrimination are at least partially learned functions, it would seem possible that further study in this area might be indicated regarding the possible relationship to the therapy of articulation defects It may be possible that new psychological techniques of learning can be developed for improving pitch perception and discrimination, and in this way further help with the problem of defective articulation

SUMMARY AND CONCLUSIONS

On the basis of clinical testing of DL for frequency of three groups of children—children with normal hearing and normal speech, children with normal hearing and articulation defects severe enough to require speech therapy, and children with impaired hearing and impaired speech development—the following conclusions were reached

1 The normal subjects were most consistent in their performance at all frequencies, while the impaired hearing

subjects were the least consistent The defective articulation subjects were between the other two groups

2 All three groups exhibited a progressive increase in the mean DL for frequency from low to high frequency

3 Statistical analysis revealed the figures obtained for performance on frequency DL's in all three groups were statistically significant In addition, the figure obtained for direction (ascending and descending) for the defective articulation group was also significant A possible clinical application of this observation was discussed

4 On the basis of both raw scores and statistical analysis of the results obtained, the performances of the defective articulation subjects on DL for frequency were found to be inferior to the normal group in almost every respect

5 On the basis of both raw scores and statistical analysis of the results obtained, the performances of the defective hearing subjects on DL for frequency were found to be markedly inferior to both of the other groups in every aspect

The findings support the hypothesis that pitch discrimination is a contributing factor in the development of speech and language for hearing impaired children The findings also suggest that pitch discrimination may be a contributory factor in the development of speech for children with articulatory defects Various clinical aspects of these conclusions were discussed The possibility of further study in the direction of improving pitch perception and pitch discrimination as an aid in improving speech development was suggested

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FIBROUS DYSPLASIA OF THE TRACHEA AND LARYNX *

Report of a Case

CHAS F ENGELKING, M D ,

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Fibrous dysplasia of the trachea and larynx has not been described to any extent in medical literature It is characterized by connective tissue proliferation but can hardly be considered a true neoplasm Because of its growth, it has the ability to cause obstruction, and for this reason behaves much like a true tumor The possibility that it was preceded by inflammation must always be kept in mind Occasionally, it is considered as an inflammatory hyperplasia, but I prefer the term "dysplasia," since this prefix signifies disordered growth or abnormality of development sometimes resulting in difficult or painful function of the organ involved

CASE HISTORY

The patient is a 54 year-old white female housewife Her chief complaint was shortness of breath, which was increasing in severity for the past 18 months She was referred to me for consultation by the State Tuberculosis Sanatorium on February 26, 1957, because of her shortness of breath which was becoming more pronounced, especially upon exertion The patient had been previously diagnosed as asthma, but failed to respond to treatment She stated that further studies in her home town revealed the presence of tubercular bacilli, and she was consequently transferred to the tuberculosis sanatorium for treatment, but the studies at the sanatorium failed to reveal the presence of tubercular bacilli in the sputum, and the radiological studies of the chest revealed a normal chest An attempt was made to bronchoscope the patient at the sanatorium by one of the chest surgeons, and he passed the scope between the cords but could not descend beyond this point as the patient became very cyanotic and nearly died before she could be revived by means of artificial respiration and oxygen

The patient gave no past history of severe throat infections, diphtheria, or laryngitis, nor did she ever have any severe bronchitis or pulmonary infections There was no history of injury to the neck

PHYSICAL EXAMINATION

The ear, nose and throat examination was normal and non contributory

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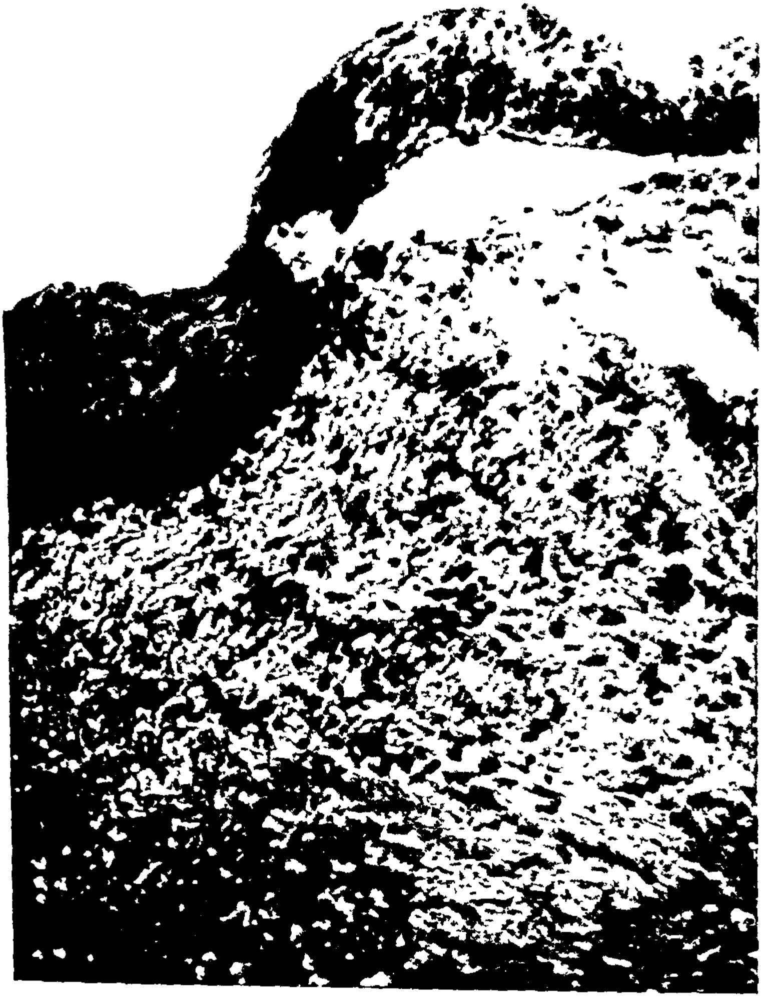

Fig 1

There were no palpable nodes in the neck, and X-ray of the sinuses was normal The larynx by indirect laryngoscopy revealed a normal epiglottis, pyriform sinuses, arytenoids, as well as normal true and false vocal cords which showed good movement on respiration and phonation Through the glottic chink could be seen an encircling type of granuloma or cicatricial type of tissue, located at about the level of the cricoid or first tracheal ring which had a central aperture of about 3 or 4 mm Oral temperature was 98 4° F, pulse was 84/minute, blood pressure 130/80 mm, and heart normal

LABORATORY STUDIES

X ray studies of the neck, as reported by the radiological department as shown on Fig 1 "soft tissue studies of the cervical area, show a symmetrical constriction of the trachea at the level of the junction between the cricoid and the first tracheal ring In relation to the cervical spine, the constriction point on the lateral view measures approximately 4 mm The constriction is rather sharply localized, and the trachea appears to be of essentially normal diameter approximately 1 to 2 cm distal to the area of narrowing" Impression Tracheal constriction at level of cricoid and first tracheal ring

Blood studies were normal and the serology and urinalysis negative Sedimentation rate was 34 mm per 60 minutes

HOSPITAL COURSE

On March 19, 1957, a tracheoplasty was done extending the incision from the thyroid notch to the sternal notch down to the trachea and laryngeal box A tracheotomy tube was placed into the trachea through the sixth tracheal ring The fifth tracheal ring was saved while the tracheal incision extended from the fourth tracheal ring through the cricoid as well as the thyroid cartilage A sharp submucous elevator was used to dissect the hard fibrous tissue from the anterior, lateral, as well as the posterior surfaces of the first tracheal ring, cricoid, and thyroid cartilage A skin graft was wrapped and sutured around a No 26 French intratracheal tube to cover the denuded surface The intratracheal tube was anchored to the tracheotomy tube below, while the upper end extended to just below the true vocal cords Two weeks later the anchor wire from the intratracheal tube to the tracheotomy tube was cut and the intratracheal tube removed from the glottic chink, using laryngeal alligator forceps and a laryngoscope The skin graft had taken well to the tracheal wall and remained well in place The overlap of skin graft beyond the denuded area of the trachea sloughed off and was coughed up by the patient The patient was discharged from the hospital April 5, 1957, or 18 days postoperative, tolerating a general diet better than before the operation, and talking fairly well in spite of the laryngeal edema that persisted

PATHOLOGICAL EXAMINATION

The surgical specimen was studied by Dr Lloyd R Hershberger[1] and reported, "The gross specimen is made up of tissue labeled as tracheal in type It is present in 11 pieces The largest of these pieces is 9×11×5 mm and the remainder of the pieces are smaller in size The smallest of the pieces is about 4 mm in its greatest diameter The tissue has a dense fibrous character that almost resembles cartilage Mucosa cannot be identified grossly The weight of this tissue is 2 grams

"The microscopic sections (see Fig 2) show tissue covered with squamous mucosa on one edge The mucosa is made up of cells four or five layers in thickness and these cells are completely uniform and orderly Occasionally one can see a transition to respiratory type of columnar epithelium Below the mucosa, broad zones of dense fibrous connective tissue are encountered Edema is found immediately under the mucosa, and then the deeper tissue is more dense in its character Blood vessels (see Fig 3) are moderately numerous and lymphocytes have infiltrated around these blood vessels The cells (see Fig 4) of the connective tissue are spindle in type and have remained completely uniform and orderly Hyalinization of the connective tissue has occurred in some areas

"Special connective tissue stains showed these fibers to be of fibrous

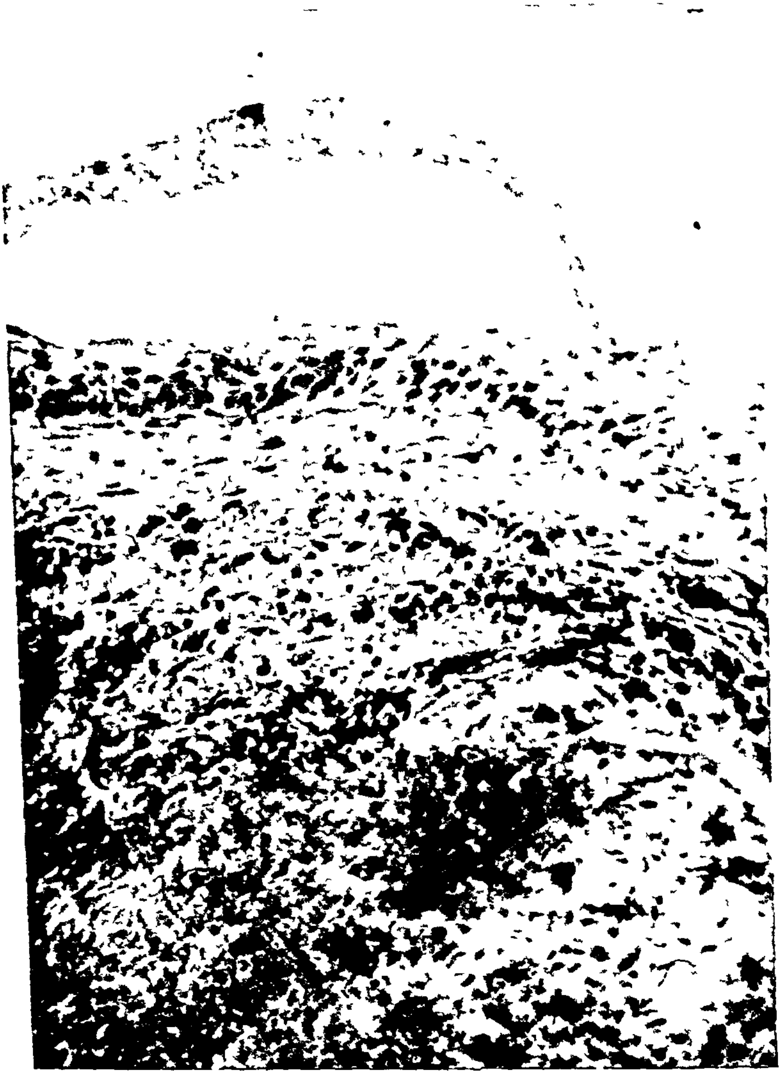

Fig 2

origin The tissue shows only this fibrous reaction and there is no evidence of a specific type of infection or malignant change

"Diagnosis Trachea showing a great amount of fibrosis all benign namely, fibrous dysplasia"

OUTPATIENT FOLLOW UP AND DISCUSSION

The tracheotomy tube was removed April 29 1957 Observation a month

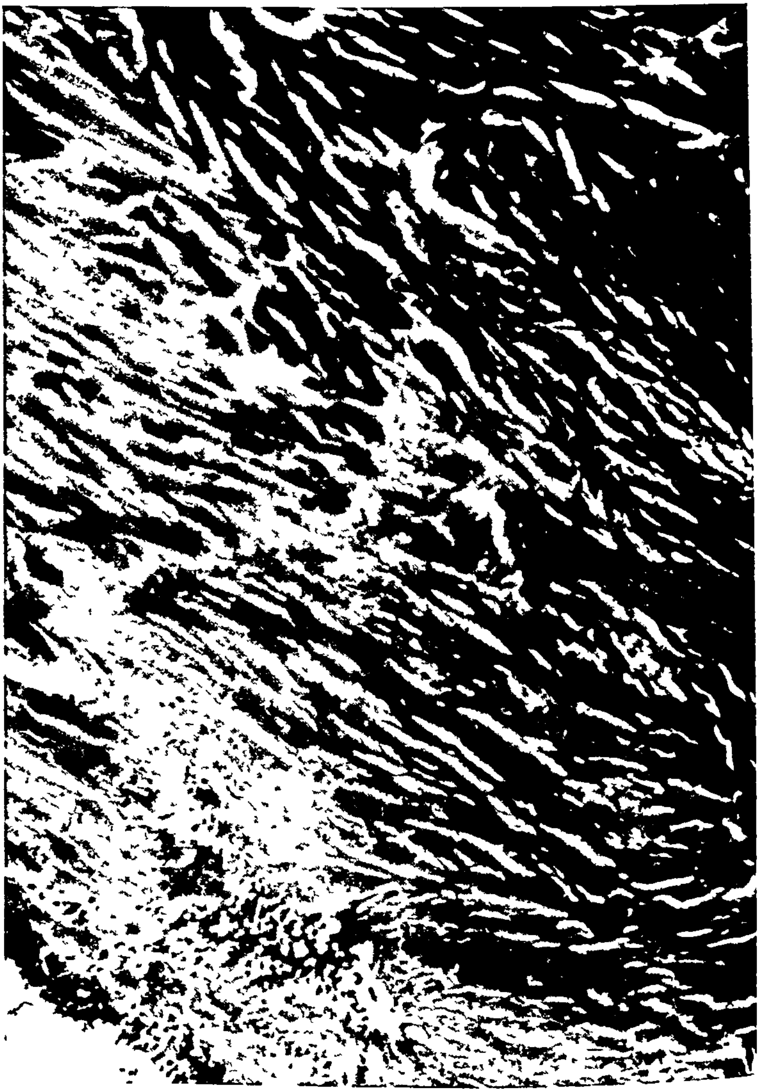

Fig 3

later revealed the skin graft to have taken well, but some thickening appeared to be developing in the area of the band, and she was started on hydrocortone, 25 mgm q i d for ten days and then 25 mgm b i d following studies made by Dr Joseph V DeSa[2] of Bombay, India, on the use of corticosteroids in the treatment of submucous fibrosis of the palate and cheek In a personal conversation with Dr DeSa on this case, he felt that it likewise was a collagen degeneration of the mucosa of the trachea and larynx, and that hydrocortone might be beneficial in prevent ing any recurrence, such as was true in his cases reported at the Sixth International Congress of Otolaryngology in 1957

The patient was continued on hydrocortone, 25 mgm b i d, until September 5, 1957, when the drug was discontinued because the aperture of the larynx and trachea was much larger, and the patient had no wheezing or shortness of breath

In a very comprehensive report in 1932, Jackson and Jackson[3] discussed benign tumors of the trachea and bronchi in great detail and named a large number of such tumors found in their case records, but no mention is made of any case

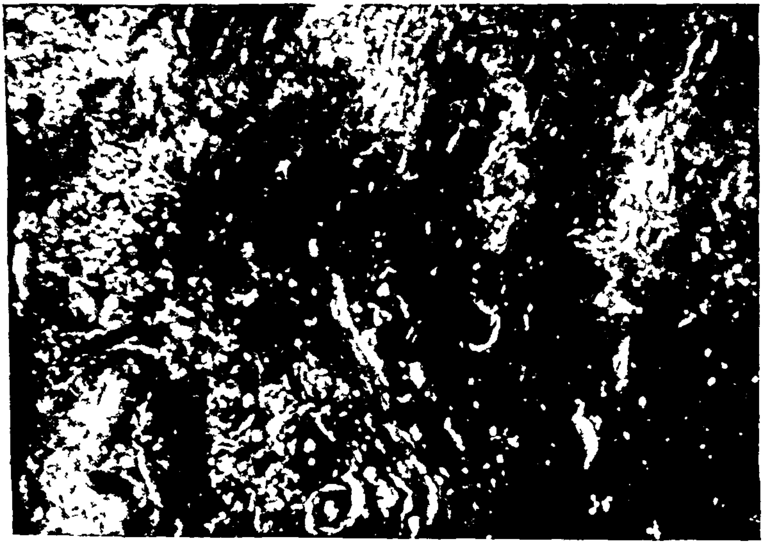

Fig 4

such as reported today Jackson and Jackson state "a growth that causes death is not benign in the strictest meaning of the word, and an inflammatory hyperplasia shaped like a tumor is not, histologically, a neoplasm, but is the clinician's primary concern in tumor-like nonmalignant obstructions of the tracheobronchial tree"

It is fairly certain that if the constricting nonmalignant band in the trachea of my patient had not been removed, death from obstruction would have been inevitable, had the band continued to grow or if she had developed an acute episode of laryngeal tracheitis unless an emergency tracheotomy had been performed

The patient was last seen on March 19, 1958, when she reported no choking or wheezing and breathing was normal Examination at that time revealed the aperture in the subglottic and trachea area within 80 per cent of normal or complete patency There was very slight crusting on the left lateral wall, while the remaining area was very satisfactory

SUMMARY

Fibrous dysplasis is rarely encountered in the head and neck, and a review of medical literature fails to reveal any references to fibrous dysplasia of the larynx and trachea An original case report of fibrous dysplasia of the larynx and trachea has been presented with the radiological and histological findings

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224 W Beauregard Ave

AMERICAN HEARING SOCIETY MOVES

National headquarters of the American Hearing Society were moved to 919 18th St , N W , Washington 6, D C The agency occupies first floor space in an eight-story building which is being remodeled and converted from apartments to offices

A METHOD OF REMOVING A NASAL HEMANGIOPERICYTOMA*

W. BURBANK WOODSON, M.D.,

Temple, Tex.

The purpose of this paper is to present a tumor that is of infrequent occurrence, to confirm methods of treatment recommended elsewhere and particularly to describe a method of intranasal excision.

In a recent article by Parker[1] and associates, it was shown that hemangiopericytoma may recur after 26 years. The case cited recurred following surgical removal in 1931 without subsequent X-ray therapy which is now used. In the case report which follows X-ray therapy was administered because of the obvious angiomatous type of the tumor. This follows Dr. K. H. Kent's[2] recommendation for Roentgen therapy for this comparatively rare tumor. It is believed that this will greatly lessen the chances of recurrence.

In 1949 Stout[3] summarized the data of 25 cases of this lesion collected up to that time. Pedowitz[4] and associates collected 144 cases between 1942 and 1954. These tumors are commonly found in the soft tissues of the body and may arise from almost any site where capillary vessels are present. McCormack and Gallivan[5] reviewed 14 cases in which hemangiopericytoma was encountered at the Cleveland Clinic between 1935 and 1954. They found that the predominant complaint was that of an enlarging mass which might occur anywhere in the body. Although there have been several reports of this tumor's occurring in the orbit,[6,7] it has not been possible to find a report of its presence in the lumen of the nose. In a report by Havens and Lockhart[8] there was no specific mention of hemangiopericytoma occurring in the nose. These authors stated that the chief treatment was in interstitial irradiation.

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The pathology of this tumor is characterized by the fact that the cells are in clusters outside of the lumen of the blood vessels This is best shown with the reticulum stain The hemangio-endothelioma and the hemangiopericytoma can be differentiated by this microscopic difference Here you may see a high and low power slide with reticulum stain in color The following detailed pathological report was received from Dr May Owen and Dr O J Wollenman, Jr Because of its interest and comparative rarity they sent their slide to the Armed Forces Institute of Pathology, where their diagnosis was confirmed Drs Owen and Wollenman's report

Gross Findings The specimen submitted, stated to be removed from the left side of the nose, consists of a mass of tissue that measured 2 5x1 7x1 3 cm Three surfaces are covered by brownish blue, mucous membrane in which a few hemorrhages can be seen On sectioning through this specimen, it is found to be composed of grayish white, firm and myxomatous, edematous tissue in which also scattered hemorrhages are evident This specimen is non-friable

Microsections of the tissue removed from the left side of the nose, reveal a very unusual tumor which is characterized by numerous vascular patterns with rather prominent endothelial cells, beyond which there is seen a uniform but highly cellular type of tumor containing an occasional mitotic figure The cells tend to be uniform in size, having an oval nucleus with finely dispersed chromatin and an indistinct cytoplasm With the reticulum stain, the vascular pattern is seen, and these cells appear to be outside the basement membrane, that is, to be pericytes They are seen in small clusters in this area and in spite of the occasional mitotic figure the nuclear arrangement is uniform There is a varying degree of collagen seen best between the vascular tumor and the mucosal surface There is no demarcating capsule to the tumor, and histologically it is seen in the line of resection both at the base and laterally We have studied this tumor extensively and feel that it should be classified as a hemangiopericytoma We are somewhat disturbed by the prominence of endothelial budding seen, but we cannot identify the malignancy With the special stain we feel that the tumor cells are actually not endothelial but, as stated, pericytes

These tumors are rather rare and usually behave as benign tumors for many years There are reported cases of malignant metastasizing hemangiopericytomas and histologically it is difficult, in many instances, to differentiate those that would behave in a benign manner from those that metastasize If not completely removed, of course, they recur, and there are reported cases in which recurrence over a period of years eventually terminated in distant metastasis The largest collected series was reported by Dr Arthur Purdy Stout in *Cancer*, Vol 2, pages 1027-1054, 1949

Pathological Findings Hemangiopericytoma, Nasal

The report of the Armed Forces Institute of Pathology sent to Drs Owen and Wollenman follows

"Members of the staff have studied the slides which you submitted in the case of Mrs J A K., but are unable to agree on the best classification for this lesion The majority agree with you that this is a vascular tumor and suggest either hemangio-endothelioma or hemangiopericytoma The small round cells which sometimes spindle out resemble glomus cells, but sometimes they appear to line vascular spaces or have a perithelial-like arrangement The organoid pattern, however, which one would expect to see in a glomus tumor is not a feature of this lesion, so that one would be forced to agree that it is either a hemangiopericytoma as you suggest, or a hemangio-endothelioma "

CASE REPORT

Mrs J A K presented a complaint of bleeding from the nose on Jan 7, 1955 On inspection of the naso pharynx, a large, light gray tumor could be observed at the level of the base of the uvula The tumor could also be seen in the left middle meatus of the nose, coming from the area of the natural ostium of the maxillary sinus This tumor was extremely vascular and had the appearance of an angioma

Method of Removal—Because of the tremendous size of the growth and excessive bleeding it was decided to precede removal with ligation of the external carotid This was done to prevent a disastrous hemorrhage on severance of the pedicle On Jan 21 1955, under local anesthesia, a very large growth measuring 21 5x1 7x1 3 cm was removed from the nose and naso pharynx by pulling the soft palate forward and up, grasping the distal end of the growth with a tonsil tenaculum, and forcing a bent nasal snare to the base of the pedicle This was done by forcing the snare against the soft palate and pulling it forward with a tonsil hook intro duced anteriorly through the inferior meatus The pedicle was then severed The bleeding was controlled with trombin packs Oxycel packs were left in place at the site of removal of the pedicle X ray treatment was started immediately 3000 r were given on each side of the nose in the area where the pedicle was severed

On Dec 31, 1958, Mrs J A K was free of recurrence

CONCLUSION

The removal of any angiomatous type of tumor should be followed with X-ray therapy to prevent recurrence

In this case the patient was fortunate in having a hemangio pericytoma amenable to intranasal excision

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103 East Central

A PRACTICAL TECHNIQUE FOR INTRANASAL ETHMOIDECTOMY AND AN EVALUATION OF ITS USEFULNESS[*][†]

FRANCIS L WEILLE, M D ,

Boston, Mass

In my experience in teaching residents at the Massachusetts Eye and Ear Infirmary the hardest surgical procedure from a practical instructional point of view is intranasal ethmoidectomy This operation has been called by Mosher[1] "the blindest and most dangerous in all surgery" It can be made not "blind" and relatively not dangerous by a simplified but effective technique, which will be described subsequently Every rhinologist should have the capacity to perform this operation at will and do it with whatever thoroughness is possible by the intranasal approach

Sometimes one sees a patient who asserts that his ethmoid has been exenterated intranasally, only to find upon inspection of the field that almost all structures are intact, including the entire middle turbinate One has the impression that occasionally a rhinologist will curette a few middle meatal anterior ethmoid cells and call this "intranasal ethmoidectomy" which, of a kind, it is, but a complete intranasal ethmoidectomy means exenteration of all cells of the labyrinth which can be reached without undue difficulty by the operator, that is, clearing of the "ethmoid box" but not of its cellular prolongations, as over the orbit Although J A Pratt[2] was able to do this without sacrificing the middle turbinate, most operators remove part or all of this structure

TECHNIQUE

The adult patient is prepared for surgery by having a phar-

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[*] Read at the Meeting of the Eastern Section American Laryngological Rhinological and Otological Society New York N Y Jan 8 1959

[†] From the Department of Otolaryngology Harvard University Medical School and the Massachusetts Eye and Ear Infirmary

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snare to the base of the pedicle This was done by forcing the snare against the soft palate and pulling it forward with a tonsil hook introduced anteriorly through the inferior meatus The pedicle was then severed The bleeding was controlled with thrombin packs Oxycel packs were left in place at the site of removal of the pedicle X ray treatment was started immediately 3000 r were given on each side of the nose in the area where the pedicle was severed

On Dec 31, 1958, Mrs J A K was free of recurrence

CONCLUSION

The removal of any angiomatous type of tumor should be followed with X-ray therapy to prevent recurrence

In this case the patient was fortunate in having a hemangiopericytoma amenable to intranasal excision

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103 East Central

tape lying at about the level of the cymba of the concha of each ear, the ends engaging each other at the occiput A cotton cap, previously placed on the head, avoids the adhesive's sticking to the hair

The nose is packed with a Mosher strip soaked in a 1/1,000 aqueous adrenalin wrung dry, with half the strip in each nasal cavity Packing of the nose is done gently but blindly with a hemostat If local anesthesia is employed, 2 per cent cocaine with 1/10,000 adrenalin is used on Dowling packs, one placed in the atrium of the nose down toward the vestibule and the second along the inferior turbinate to the posterior tip of the middle turbinate

There are six types of mechanical problems which face the surgeon at the beginning of the operation

1 A deviation of the septum toward the side being operated on,

2 Complete filling of the nasal cavity with polyps and obliteration of landmarks thereby,

3 A straight septum or a deviation of the septum away from the operative side with signs of infection or a few polyps, but with good visualization of the middle turbinate,

4 Turgescence of nasal mucosa in cases of vasomotor rhinitis even after shrinkage,

5 A narrow anterior and wide posterior ethmoid as defined by X-ray examination,

6 A narrow nose and narrow ethmoid with poor definition of the middle turbinates

Correction of the deviated septum toward the side of the labyrinth to be exenterated aids a great deal in the approach to the ethmoid cells Less time is required usually to correct such a septum than is wasted in accepting its mechanical annoyance The septal resection is *not* limited, and is carried about 1 to 1 5 cm higher than the inferior border of the middle turbinate This border is about 2 5 to 3 cm from the cribriform plate in the average nose maseal enema the night before and 1 gm of chloral hydrate at bedtime Appropriate pre-operative medications one hour before operation are demerol, 50 mg, and atropine sulfate, 0 6 mg In patients having asthma, hay fever, hives or eczema, or a family history of these conditions, it is well to avoid opium derivatives, aspirin, and barbiturates by mouth

I prefer general anesthesia, chiefly for convenience, because the operation is often combined with several other procedures Intratracheal gas-oxygen-ether is the usual combination of anesthetic agents, except when subepithelial diathermy coagulation cauterization of the inferior turbinates is necessary as a secondary procedure, in which case intravenous pentothal and intratracheal nitrous oxide-oxygen are used If only one ethmoid sinus is to be exenterated without other surgery, local anesthesia is satisfactory, using 2 per cent procaine with 1/50,000 adrenalin, 1 to 2 cc to block the nasociliary nerve and the posterior ethmoidal nerve on the medial superior wall of the orbit near the anterior and posterior ethmoidal foramena, 1 cc of the same solution is injected into the region of the sphenopalatine ganglion through the pterygopalatine canal With general anesthesia, induction is made with the patient *lying down*—after which he is placed in a sitting position with care to watch the blood pressure levels when the change of position is made With local anesthesia the patient is in a sitting position before starting the surgery

With unconscious patients, a postnasal pack is placed in the nasopharynx and secured externally with silk strings attached to it through the mouth About a yard of uterine tape moistened with normal saline is packed around the pharyngeal part of the intratracheal tube The patient's face, nasal vestibules and the nasal cavity just behind each vestibule is prepared with 1/1,000 aqueous zephiran Surgical cleanliness is employed at all times, even though the operator will be working in a non-sterile field The purpose is not to complicate the procedure by adding organisms not already present and to proceed as though the operator actually had a sterile field The middle of a sterile towel is draped over inch-wide adhesive and strapped firmly across the upper lip with the

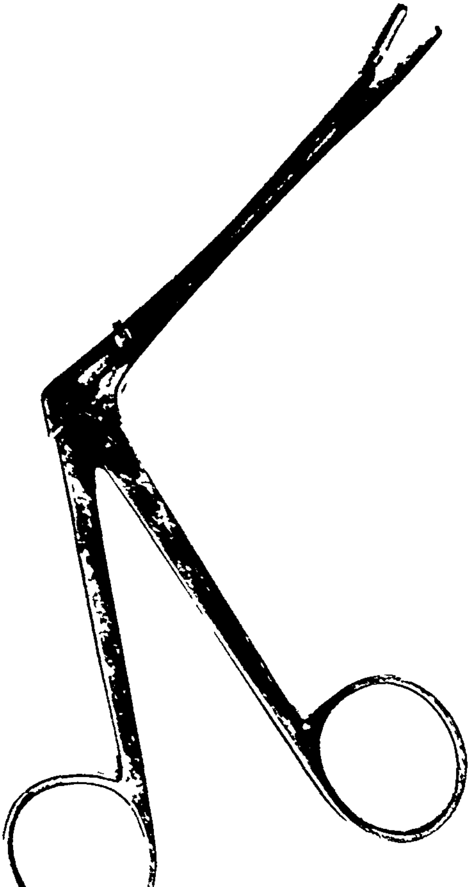

Fig 1 Greene Punches

with the sphenoid The curette is again swept downward toward the floor of the nasal cavity This maneuver will permit the small end of a Faulkner curette (see Fig 2) to enter a large posterior ethmoid cell The cutting edge of the ring of this instrument is kept in the frontal plane, with the flat part of the ring always parallel to the orbital plate of the frontal

If the nasal landmarks can be made out without particular difficulty, the middle turbinate is excised by cutting obliquely across it with turbinate scissors, making certain that the cut goes as high as the insertion or lamella This usually requires closing the turbinate scissors twice instead of once in two steps from before backward An ordinary nasal polyp snare threaded with *tonsil* wire is then engaged over the free anterior end of the middle turbinate as near as possible to the lamella, thereby excising about the anterior third or half of this turbinate A beak-shaped middle turbinate stump remains posteriorly and is left as a landmark temporarily

The ethmoidal bulla which always contains one posterior cell and one or two anterior cells is then entered with a Lempert zero or double-zero curette, which is swept downward

In attempting to enter the bulla care must be taken not to confuse the medial superior roof of the antrum with the ethmoidal lateral mass, since this would cause unnecessary damage to the orbit and its contents If the bulla is not easily identified, a flat, thin, blunt-edged septal dissector can be used to palpate very gently the region of the middle turbinate overhang in the direction of the olfactory slit without touching the cribriform plate This in conjunction with estimating the size of the ethmoid in antero-posterior X-ray films will permit a curette to be plunged blindly into the bulla by going backward and slightly upward, but staying well away from both the roof of the antrum and the region just identified by palpation with a septal dissector as described Once a small opening has been made into the ethmoidal bulla, the upper blade of a Greene punch (see Fig 1) is placed inside the bulla cell with the lower jaw lying inferior to the cell, the tissue thereby engaged is evulsed This area is then enlarged further with one or two bites of the same punch Any polypoid tissue within the cells is stripped away No attempt is made at this point to enter any of the *anterior* ethmoid cells not contained in the bulla

With the same Lempert curette a puncture is made into the posterior superior portion of the bulla cell in the direction of the lowermost posterior ethmoid cells, making a common wall bone The curette is pulled from behind forward, keeping *away* from the region of the cribriform plate and risking possible damage to the thin orbital wall, which rarely occurs The resulting mass of tissue, which is pulled downward and forward into the nasal cavity, will open up the surgical field in such a manner that the operator can see a small part of the orbital plate of the frontal bone, and usually a common wall of another posterior ethmoid cell

Since the operator is not certain as to the exact plane of this common wall in relation to the choana, he will then excise with a polyp snare, threaded with tonsil wire, all of the remainder of the middle turbinate except a small posterior stump This small stump is left so that sphenopalatine vessels entering the nose through the foramen can be easily clamped These vessels come in just superior to the posterior tip attachment and lie chiefly on the external side of the curved stump They are clamped with a small, long, straight hemostat and rarely cause any serious trouble It is a curious fact, however, that in patients who have had allergy of one variety or another, barbiturate intravenous anesthesia is sometimes associated with a *rise* in blood pressure during the operation, which may cause extra bleeding from these and other vessels Any polyps which happen to interfere with good visualization of the posterior ethmoid already entered are excised For this purpose I prefer a Greene punch It is now possible to visualize the postnasal pack at the choana This permits orientation of the operator in relation to any remaining posterior ethmoid cells lying anterior to the face of the sphenoid These cells are then excised with particular care to avoid the lateral posterior superior relationship with the sphenoid since that is the danger point for possible damage to the optic nerve In 171 skulls studied at the Harvard Medical School, posterior ethmoid cell dehiscences in near-contiguity to the optic nerve were found in only two There are usually only three or four posterior cells at most, and it is easy to dissect them because of their large size The same method described for exenteration of the bulla is utilized

The operator is then prepared to exenterate the four remaining groups of anterior ethmoid cells[1] all at once, by plac-

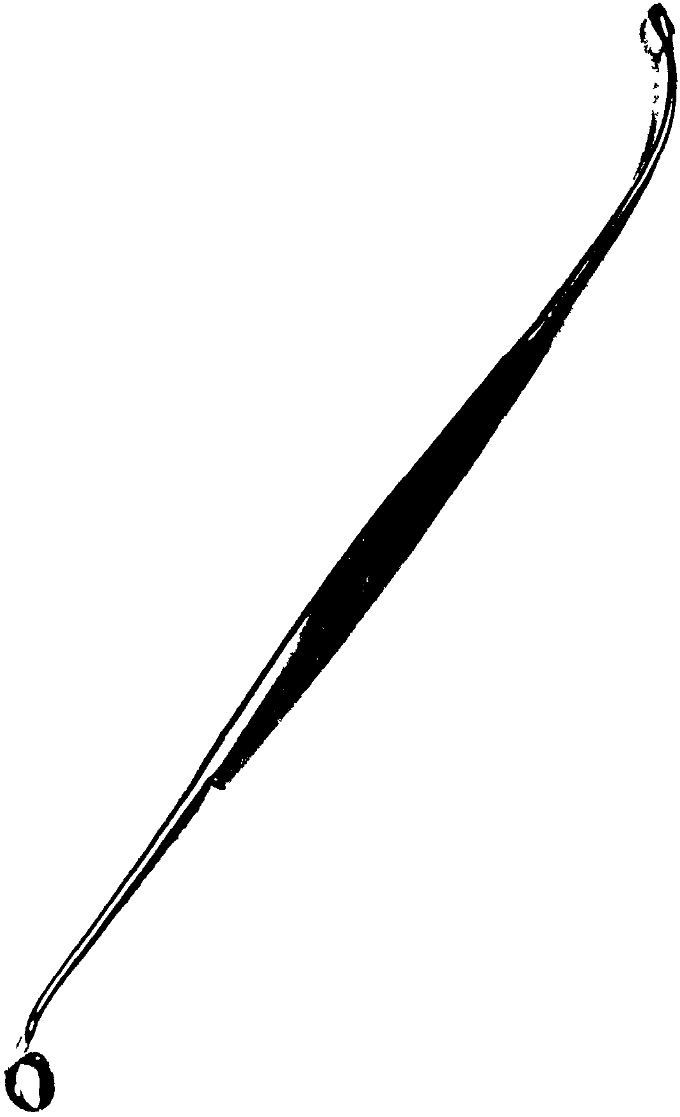

Fig 2 Faulkner Curette

indicated Other procedures can be easily combined with the foregoing such as intranasal antrostomy, the making of a window into the sphenoid through the common wall of this sinus with the posterior ethmoid, excision of an hypertrophied posterior tip of the inferior turbinate ("mulberry polyp"), and subepithelial diathermy coagulation cauterization of the inferior turbinates

It is better *not* to pack the nasal cavities postoperatively, except when submucous resection of the septum has been done simultaneously, or unless there appears to be a serious risk of hemorrhage, as judged by the degree of bleeding during the surgery In either case sterile finger-cot packs (covering Mosher strips), lubricated with sterile vaseline, can be safely placed near the floor of each nasal cavity, rather than very high They are secured with heavy silk mattress sutures near the ends protruding from the vestibules, tied to each other, and the ends of the silk, cut long, are taped to the dorsum of the nose

The mouth packing is removed, together with the post-nasal pack, while simultaneously aspirating the pharynx with suction At this stage the patient should be sufficiently conscious to gag actively If the nose has been packed, mouth breathing is assured by use of an airway between the teeth, and close recovery-ward observation until the patient is conscious

Nasal packs should never be placed in the nose in an unconscious patient in whom there is no pharyngeal packing, unless the operator takes precautions to prevent possible aspiration, such an accident has been known to happen with great speed

Postoperative orders include

1 Watch for hemorrhage,

2 Pulse and blood-pressure every 15 minutes for three hours, then frequently,

3 Elevate the head moderately,

4 Ice cap to top of head, *not* to nose,

5 Fluids and food by mouth as soon as tolerated, ing the small ring of the Faulkner curette against the orbital plate of the frontal bone and sweeping it forward Remembering that the instrument will lie *above* the horizontal plane of the cribriform plate, he will keep the instrument directed *away* from this structure and carry it straight forward and slightly toward the orbital side of the field Since the instrument has an inside diameter of 5 mm and the anterior ethmoid cells occupy about this amount of space from side to side, the cells of the frontal recess will be exenterated at the end of the sweep forward, while the downward sweep to the nasal cavity will lie against the lacrimal cells and part of the agger nasi cell It is then a simple matter to trim away with a Greene punch the remaining anterior cells, including those around the hiatus semilunaris This will complete the removal of the major portion of the ethmoid cells, it is then possible to use the same septal dissector as described above to palpate, with the utmost gentleness, the position of the cribriform plate and to excise a portion of the middle turbinate overhang, or to trim this structure on its lateral aspect This trimming is done in such a manner as to remove conchal bone and approximate mucosal edges to each other All tissue fragments and bone chips are removed as dissected by using both instruments and spot suction with various sizes of Pilling suction tubes In many cases the ostium of the frontal sinus will be seen, or a malleable thin silver probe will enter it easily The mucosal lining of the ostium should not be disturbed, but abnormal ethmoidal mucosa near it may be stripped away

The superior and supreme turbinates are usually left *in situ*, but not invariably

In an "easy" ethmoid the exenteration can be done in 20 to 30 minutes, in a difficult case the time required may be rarely an hour If polypoid degeneration has filled the nasal cavity with polyps and made the middle turbinate unrecognizable, the polyp masses can be removed until the choana, inferior turbinate and septum are well defined Then the exenteration can proceed as described

It is now possible to exenterate the second ethmoid if this is much of the affected nasal cavity into a quadrangle from a rough triangle, thus widening markedly the upper half of the lateral wall of the nasal air space

b It permits exposure of the frontal sinus ostium from below, aiding thereby in drainage if infection is present in this sinus

c The great majority of the ethmoid cells can be excised, and recurrent polyposis of the area can be easily controlled by excision with *aural* steel wire snares, diathermy needle cauterization or dessication when necessary

d Removal of the middle turbinate may be a great advantage in vasomotor rhinitis as well as in some types of sinus disease

e It can be combined easily with one or more other intranasal surgical procedures, including submucous resection of the septum, exenteration of the second ethmoid, intranasal antrostomy, subepithelial diathermy cauterization of the inferior turbinates, resection of an hypertrophied posterior tip of the inferior turbinate, mucous polypectomy, etc Any or all of these procedures may be required for the relief of a chief complaint of nasal obstruction (rarely achieved by intranasal or other sinus surgery alone)

f Although technically more difficult, and requiring greater experience it is mechanically easier than external ethmoidectomy

3 Purulent ethmoiditis alone can usually be relieved without surgery by a combination of local treatment and appropriate antibiotics, unless a complication such as orbital abscess has occurred Then the *external* operation is indicated

4 The factor of allergy often requires evaluation For example, an examination of the nose and throat in 500 unselected asthma patients, as listed in Table I, showed a high percentage of sinus involvement as well as nasal polyposis and vasomotor rhinitis

A major purpose of this paper is to aid the rhinologist to

6 Demerol, 50 mg s c every three hours when necessary for pain A smaller dose is given if the patient weighs less than about 150 pounds

7 Chloral hydrate, 1 gram at bedtime if the patient is not nauseated, this dose may be lessened as stated in 6,

8 Antibiotics are not usually necessary, if given to patients with a history of asthma, hay fever, hives or eczema, the duration should be short, and an antihistamine as well as yogurt and vitamin B complex may be prescribed at the same time Spinal fluid antibiotic, or sulfonamide concentrations, can be disregarded unless the operator suspects dural damage as possible

Fluid replacement therapy is not a problem in most cases, a fluid intake of two liters during the first 24 hours after operation, and of three liters daily thereafter is desirable The nasal packing, if present, is removed on the morning after operation and not replaced

No local nasal treatment whatsoever need be undertaken in the hospital or office prior to the tenth postoperative day Then, at the office, dried secretions can be gently removed, keeping in mind that healing epithelization occurs on the *deep* surface of crusts, and that epithelium must not be torn away upon freeing the nose of such crusts The least local treatment possible is done during the first two weeks after operation, thereafter very little is necessary except observation and adequate treatment of any nasal polyposis This subject is dealt with in a separate publication [3]

EVALUATION

1 Psychological advantages accrue from the fact that the patient is in most instances willing for the doctor to carry out whatever *intranasal* surgery he thinks necessary, yet the same patient will frequently refuse elective operations which result in a scar on the face, no matter how inconspicuous

2 Mechanical Advantages

a In vasomotor rhinitis complicated by ethmoidal sinusitis, intranasal ethmoidectomy converts the frontal plane of *b* Cortisone, 50 to 200 mg intramuscularly two hours before operation

c About two hours before operation 100 mg of hydrocortisone in 500 cc of 5 per cent or 10 per cent glucose intravenously is started and continued as a drip for about eight hours This drip is repeated in the same dosage when the first one is completed, unless the patient is able to take the same amount of hydrocortisone by mouth in divided doses over an eight-hour period

d The patient is then returned to whatever dose of steroid he was taking prior to entering the hospital

2 In patients who have not had any steroid therapy, it is likely that the normal "alarm" reaction to any type of major operation will release enough Cortisone physiologically beyond the normal body requirements of about 35 mg daily to result in temporary improvement in allergy manifestations in many cases It is only in recent years that otolaryngologists and other surgeons have recognized this fact

3 Because of the multiplicity of nasal lesions usually present, intranasal ethmoidectomy is ordinarily only one of several procedures carried out in surgical treatment, which may include the Caldwell-Luc antrum and measures required for good mechanical and physiological functioning of the nasal cavities[6]

4 In patients having vasomotor rhinitis without asthma, about 18 per cent will develop asthma sooner or later[6] with or without any nasal operation

5 After sinus surgery, improvement in the asthma is likely to occur in about 50 per cent of the cases with a slightly higher favorable response if the patient is followed for many years[7] Since some asthmatics improve spontaneously, and many forms of medical treatment relieve asthma, the rhinologist should be cautious in giving his operation credit even in very favorable end results In my own personal experience, where 105 asthma cases had intranasal ethmoidectomy, together with other nasal surgery at the same time,[7] 56 patients (55 per cent) were improved or cured of asthma over a follow-up period of six have instantly available a practical intranasal surgical technique for dealing with ethmoid pathology in these cases when, in the operating room, he finds this to be necessary, or a decision is made for such surgery in the pre-surgical evaluation of the patient.

The allergist should, obviously, be given the opportunity to study and treat any patient having vasomotor rhinitis, asthma or allied conditions. Since his results in vasomotor rhinitis and nasal polyposis are often poor,[3] he will frequently request aid from the rhinologist, or the patient will insist upon a rhinological opinion. The allergists themselves are divided in regard to the effectiveness of any form of surgical treatment of the sinuses[4,5] in asthma and allied conditions. The rhinologist should keep in mind the following points.

TABLE I

Nose and Throat Lesions in 500 Unselected Asthma Patients

Lesion	Cases	Extrinsic	Intrinsic	Miscellaneous
Pansinusitis (unilateral or bilateral)	46	11	34	1
Sinusitis—one or more (unilateral or bilateral)	316	136	180	0
Vasomotor rhinitis	223	111	109	3
Polypi	211	81	128	2
Surgically deviated septum	95	47	46	2

1. If prolonged steroid therapy has been part of the medical treatment, any surgery may entail grave risk of lengthy collapse of blood pressure during or within hours after operation because of an inadequate alarm reaction. The word "prolonged" may be defined as at least six months of doses substantially more than 35 mg of Cortisone (or equivalent doses of other steroids) daily. Three months or less of such treatment can usually be disregarded, but beyond this the surgeon should take proper precautions to protect the patient from the risk of severe hypotension of several hours' duration. He can do this by refusing any surgery or by ordering the following:

a. Cortisone, 50 to 200 mg by mouth the night before operation.

b Cortisone, 50 to 200 mg intramuscularly two hours before operation

c About two hours before operation 100 mg of hydrocortisone in 500 cc of 5 per cent or 10 per cent glucose intravenously is started and continued as a drip for about eight hours This drip is repeated in the same dosage when the first one is completed, unless the patient is able to take the same amount of hydrocortisone by mouth in divided doses over an eight-hour period

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6 The local result in the nose will be found satisfactory following intranasal surgery in about 75 per cent of the patients,[6] providing that in the follow-up period recurrent polypoid degenerative changes are dealt with properly[3]

7 It is best to have the patient understand that any nasal surgery is done for the purpose of improving the local condition of the nose, and that it is not done to "cure" asthma, although it is common experience that sometimes the asthma will improve following such surgery

SUMMARY

1 Intranasal ethmoidectomy is difficult for residents being trained in rhinology to learn

2 A practical method which is described in this paper may aid the beginner or expedite expert technique

3 The usefulness of the procedure is evaluated in terms of everyday problems presented in ordinary rhinological practice

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INTRANASAL ETHMOIDAL SCHWANNOMA

Report of Two Cases

CHARLES I JOHNSON, M D,*
Boston, Mass.
and
MERRILL LINEBACK, M D,
College Park, Ga

Unusual bleeding from any orifice of the human body should make one suspicious of malignancy This is especially true when one encounters epistaxis While most frequently seen in trauma about the nose, hypertension, ulceration and hemangioma of the septum, acute upper respiratory infection, and hereditary hemorrhagic teleangiectasia or Rendu-Osler's disease, nosebleed is often the first sign of the presence of an intranasal tumor It is rather unusual for a nerve tumor to cause nasal bleeding, and for this reason as well as the rare etiology, we report the following two cases:

Case 1 Mrs M W a 31-year-old housewife, first noted nasal hemorrhage in October of 1949 "after taking gas" presumably for tooth extraction Again in January of 1950 after a blow to the left side of the nose epistaxis ensued, and the nose was cauterized in the office of her local physician X-rays of the sinuses one week prior to admission to the Massachusetts Eye and Ear Infirmary on April 20 1950 revealed a probable cyst of the left ethmoid region Past history revealed that during the Winter of 1943 1944 she had allergic rhinitis that subsided following removal of nasal polypi She did not remember which side had been involved A biopsy apparently was not done nor the excised tissue examined under the microscope

Under intravenous pentothal anesthesia a left intranasal ethmoidectomy was performed A mass involving the left ethmoidal labyrinth and partly attached to the septum by adhesions was removed with a wire snare and ring punch The specimen was cauliflower-like and had a volume of about ten cubic centimeters Diagnosis by Dr Tracy Mallory was 'Neurofibrosarcoma Areas of recent hemorrhage with reaction and fibrosis An occasional mitosis is seen" (see Fig 1)

At last correspondence with her in September 1958 she wrote that she was not at all well and an appointment was made for an examination

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*Deceased Sept 30 1958

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More recently the term *malignant Schwannoma* has been preferred to that of neurogenic sarcoma or even neurofibrosarcoma Because of the unusual pathological diagnosis we put the case on the shelf for a while, hoping to find another one in clinical practice Time went by, and we forgot about it until the Spring of 1958, when one of us (M L) had a referred case from South Georgia, of a firm, intranasal bleeding mass The literature was thoroughly combed, using the Quarterly *Index Medicus* and the AF reference list from 1948 through May, 1958, and not a single tumor of such description could be found in the world literature

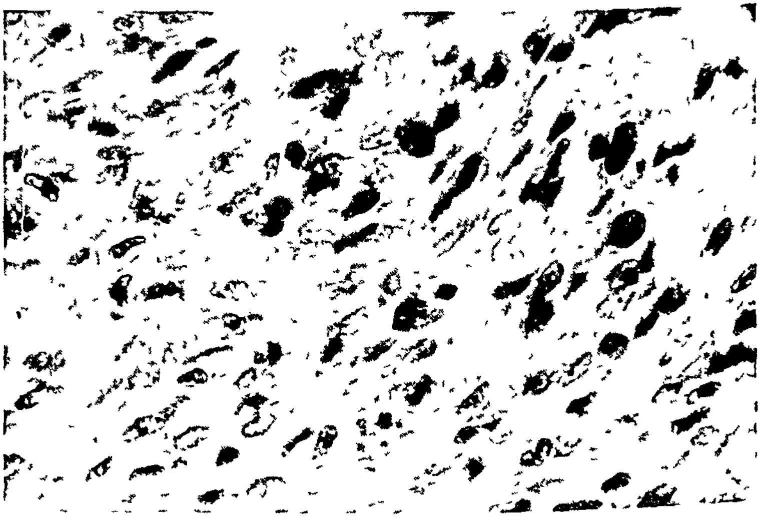

Fig 1 Oil immersion view of tumor in Case 1 showing the pleomorphism that suggested a diagnosis of neurofibrosarcoma Re-examination eight years later changed this opinion to that of Schwannoma a benign tumor malignant 'by position" only

Case 2 Mr C W, a 28 year old sawmill operator, was examined and found to have a mass in the right ethmoid region associated with obstruction to breathing on that side for a period of about three months' duration X rays revealed an opaque mass in the right ethmoid region without breakdown of bone A biopsy was taken and reported as a benign Schwannoma (see Fig 2)

Operation at this time was refused by the patient in spite of the "malignant by position" aspect and the danger of erosion of bone and extension of infection to the meninges as a possible sequel

Because of the similarity of the two cases re-examination of the slides from Case 1 was made and the original diagnosis of *neurofibrosarcoma* was changed to merely *Schwannoma* One pathologist mentioned the fact that from the microscopic picture alone, it was difficult to differentiate between the two, and that the only way to be sure was whether the patient was alive or not after a few years, another stressed the incompleteness of our knowledge of nerve tumors in 1950 and that these cases illustrated how opinion and further knowledge and study of these unusual tumors can change over the years We just didn't know enough about the development nor the various histological types in 1950 to be as accurate as we are now

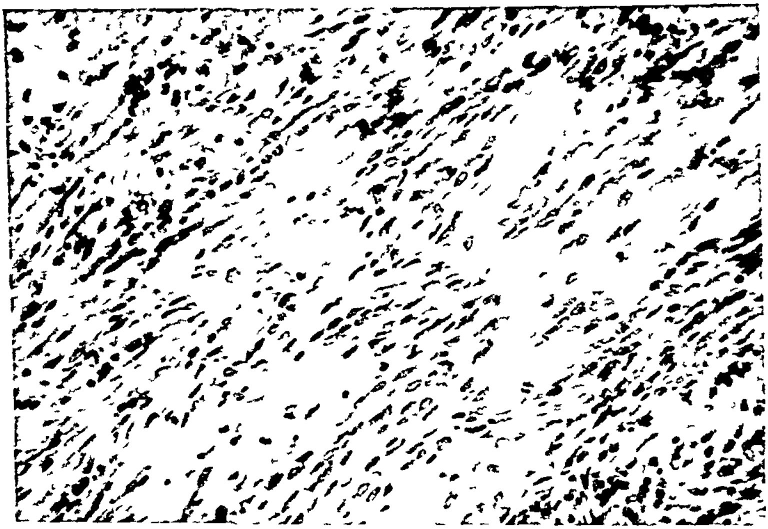

Fig 2 High power magnification of tumor in Case 2 showing the palisading effect which is characteristic more of a benign lesion Pleomorphism shows up well here also

The literature review did reveal a case of malignant Schwannoma of the tip of the nose[1] following intensive X-ray therapy for eczema Ash and Raum[2] mentioned a fibrosarcoma of the maxillary sinus, and a fibrosarcoma of the ethmoid was noted by Stratton[3] in 1957 Endonasal Schwannoma was discussed in 1951 by Gonzalez Loza and Rosenzvit [4]

SUMMARY

These two cases of ethmoidal Schwannoma are illustrative of an unusual type of intranasal nerve tumor first manifesting by the rather common symptom of epistaxis They further prove that not all intranasal masses are hemangiomata, granulomas or mere polyps It is to be emphasized that removal of obstructive bleeding masses and examination under the microscope is the only way to be sure of our pre-operative diagnosis

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The 1959 British Columbia Oto-Ophthalmological Conference will be held in Vancouver, B C, on May 28th to 30th, 1959 Guest speakers will be Dr Alfred Huber, Assistant to Professor Amsler, Zurich, Switzerland, in Ophthalmology, and Dr Theo E Walsh of St Louis, Mo, in Otolaryngology All Otolaryngologists and Ophthalmologists in the Pacific Northwestern area are cordially invited to attend

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Section on Laryngology, Otology and Rhinology

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(Rather than assigned discussers, each paper, except those of the Guest of Honor and the Chairman, will be followed by an open discussion period, questions and comments from the floor are encouraged.)

Tuesday, June 9—2 P.M.

Prof. Dr. H. H. Naumann, Wurzburg, Germany—
Intravital Observations of the Nasal Mucous Memberane (Film)

George M. Coates, M.D., Philadelphia, Pa.—
Address of Guest of Honor

Gordon D. Hoople, M.D., Syracuse, N. Y.—
Modern Otolaryngology

F. W. Davison, M.D., Danville, Pa.—
Laryngeal Obstruction in Children

Ben T. Withers, M.D., Houston, Tex.—
Facility in T&A Management: Conclusions from 2400 Consecutive Cases

Joseph H. Ogura, M.D., St. Louis, Mo.—
Cancer of the Pharynx, Larynx and Upper Esophagus; Surgical Aspects

Business Meeting

Report of Section Delegate to AMA House of Delegates—
Gordon F. Harkness, M.D., Davenport, Ia.
Dean M. Lierle, M.D., Iowa City, Ia., Alternate

Report of Section Representatives to Board of Governors of American College of Surgeons—
Roderick Macdonald, M.D., Rock Hill, S. C.
Edley H. Jones, M.D., Vicksburg, Miss.
John J. Conley, M.D., New York, N. Y.

Report of Nominating Committee—
F W Davison, M D, Danville, Pa
Louis E Silcox, M D, Philadelphia, Pa
John D Singleton, M D, Dallas, Tex

Wednesday, June 10—2 P M

J W HAMPSEY, M D, Pittsburgh, Pa—
Current Concepts of Etiology and Management in Otolaryngic Allergy

VICTOR R ALFARO, M D, Washington, D C
Address of Section Chairman

HENRY S KAPLAN, M D, San Francisco, Calif—
New Horizons in the Radiotherapy of Malignant Disease

JOHN A KIRCHNER, New Haven, Conn—
Facial Bone Injuries

M R HIMALSTEIN, M D, Bay Pines, Fla—
Obliterative Frontal Sinus Surgery Using Gelfoam

J M RAVID, M D, New York, N Y—
Malignant Melanoma of the Nose and Paranasal Sinuses, and Juvenile Melanoma of the Nose

Wednesday Evening, June 10—6 30 P M

Social Hour and Dinner Honoring the Guest of Honor of the Section, Dr George M Coates

Thursday, June 11—2 P M

JOSEPH L GOLDMAN, M D, and HARRY ROSENWASSER, M D, New York, N Y—
Current Concepts of the Management of Otitic Infections

MERLE LAWRENCE, Ph D, Ann Arbor, Mich—
Ear Physiology

EDWARD W HARRIS, M D, Columbus, O—
Symptoms Referable to the Eustachian Tube

GEORGE KELEMEN, M D, Boston, Mass—
Maternal Diabetes and Congenital Deafness

JOSEPH SATALOFF, M D, Philadelphia, Pa—
Stapes Mobilization with Long-Standing Otosclerosis

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Polyethylene in Middle Ear Surgery

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STRUCTURE AND COMPOSITION OF SALIVARY CALCULI *†‡

JAMES A HARRILL, M D ,
J STANTON KING, JR , Ph D ,
and
WILLIAM H BOYCE, M D ,
Winston-Salem, N C

INTRODUCTION

Salivary calculi are composed of an inorganic crystalline body and an organic matrix This report is concerned with the identification and amount of the inorganic crystalline substance and the histologic, histochemical and biochemical characteristics of the organic matrix

METHODS

A total of 58 calculi surgically removed from the salivary glands have been included in the present study Analyses were conducted over a period of five years, and hence not all calculi have been subjected to all analyses The small size of many calculi precluded complete analysis of each stone In

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*Read at the Meeting of the Southern Section of the American Laryngological Rhinological and Otological Society Atlanta Ga Jan 23 1959

†From the Department of Otolaryngology Department of Biochemistry and Department of Urology of The Bowman Gray School of Medicine of Wake Forest College and The North Carolina Baptist Hospital Winston-Salem N C

‡Supported by Grant A-259 from the Institute of Arthritis and Metabolic Diseases of the National Institutes of Health Department of Health Education and Welfare and by grants from the Mary Reynolds Babcock Foundation Winston-Salem N C The United Medical Research Foundation of North Carolina and Grant 151 from the Committee on Research The Council on Pharmacy and Chemistry The American Medical Association

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Notice of each book or monograph, including title, name of author, publisher, pagination, price, etc, will be presented in these notices so that our readers may have all data at their disposal for further inquiry

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The matrix content of 18 per cent for salivary calculi is considerably greater than the 3 per cent of the average urinary calculus Urinary calculi have been found to contain as much as 66 per cent by weight of matrix, and such calculi are roentgenolucent by ordinary diagnostic techniques[4] No roentgenolucent salivary calculi have been analyzed in the present series No salivary calculus has been found to be free of an organic matrix

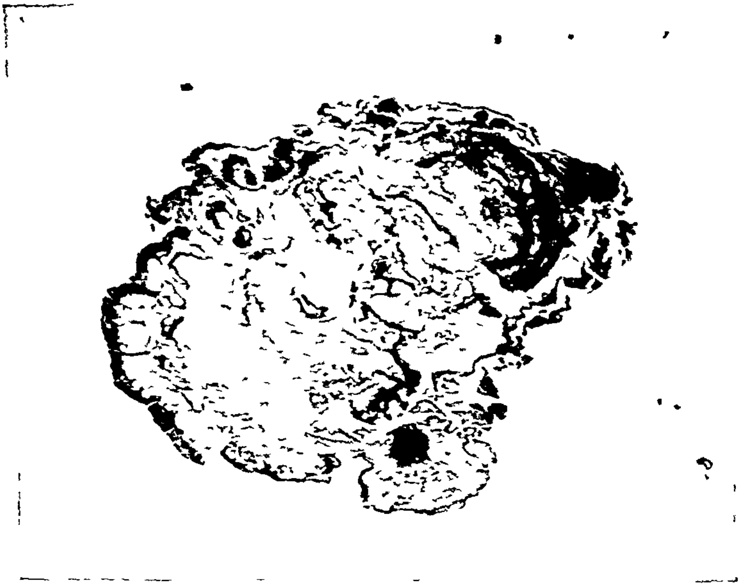

Fig 1 Cross section of decrystallized submaxillary calculus PAS stain Magnification x 22.

Organic Matrix As in urinary calculi the diffusion chelation technique for removal of the crystals has left the matrix as a perfect cast of the original calculus in every specimen (see Fig 1)

Histologic and Histochemical Characteristics The organic matrix is present from center to surface of all calculi The matrix stains poorly with hematoxylin

The periodate Schiff leucofuchsin reaction is brilliantly positive for the entire matrix (see Fig 2) Treatment of the general, calculi weighing more than 150 mg were analyzed separately and smaller calculi were pooled for analysis The average dry weight for the 58 calculi was 270 mg with a range of 27 to 5670 mg The inorganic constituents were determined by combinations of chemical and spectroscopic analysis[1,2] The organic matrix was recovered by diffusion chelation of the inorganic constituents in 5 per cent EDTA adjusted to pH 7 8 Whole matrices of 14 calculi were fixed in 10 per cent formalin, embedded, serially sectioned to a thickness of 8 mμ and studied by the following stains and histochemical reactions *1* hematoxylin and eosin, *2* periodic acid Schiff leucofuchsin reaction, *3* aqueous toluidine blue, Sudan black, and *5* Von Kossa method for sites of "calcium binding activity"[3,4]

TABLE I

Approximate Inorganic and Matrix Composition of 34 Salivary Calculi (Expressed as Per Cent of Dry Weight)

Constituent	Average	Range
Calcium	31	26 36
P (As Phosphate)	48	41 54
Organic Matrix	18	8 38

Magnesium carbonate and ammonium were present in small quantities but were not quantitatively determined

The pooled matrices from 12 of the larger calculi were recovered by lyophilization, hydrolyzed and examined by paper chromatography for amino acid and carbohydrate constituents as previously reported[5]

RESULTS

Inorganic Composition Table I is a summary of the inorganic and organic matrix composition of 34 calculi Calcium in the form of calcium phosphate (probably hydroxylapatite) was the principal constituent of all calculi Magnesium was present in the range of a trace to 2 per cent (wt /wt) of all calculi Trace amounts of ammonium ions were detectable in all calculi, but oxalate was not identified in measurable quantity

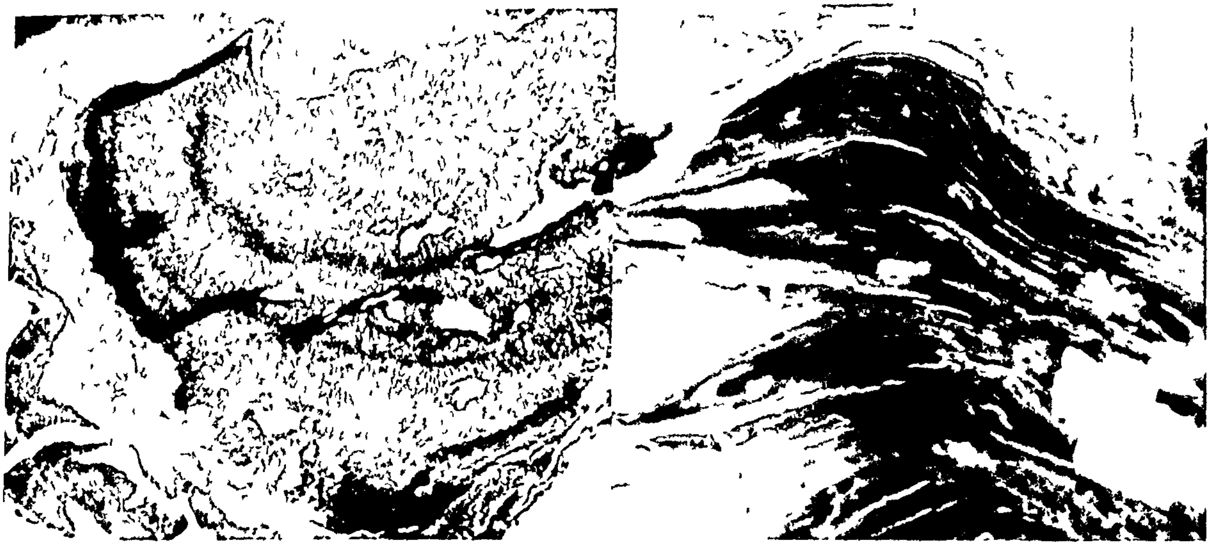

Fig. 1 Cross section of several decrystallized submaxillary calculi to illustrate tendency to laminations in matrix A—PAS stain, magnification × 85 B—PAS stain magnification × 85

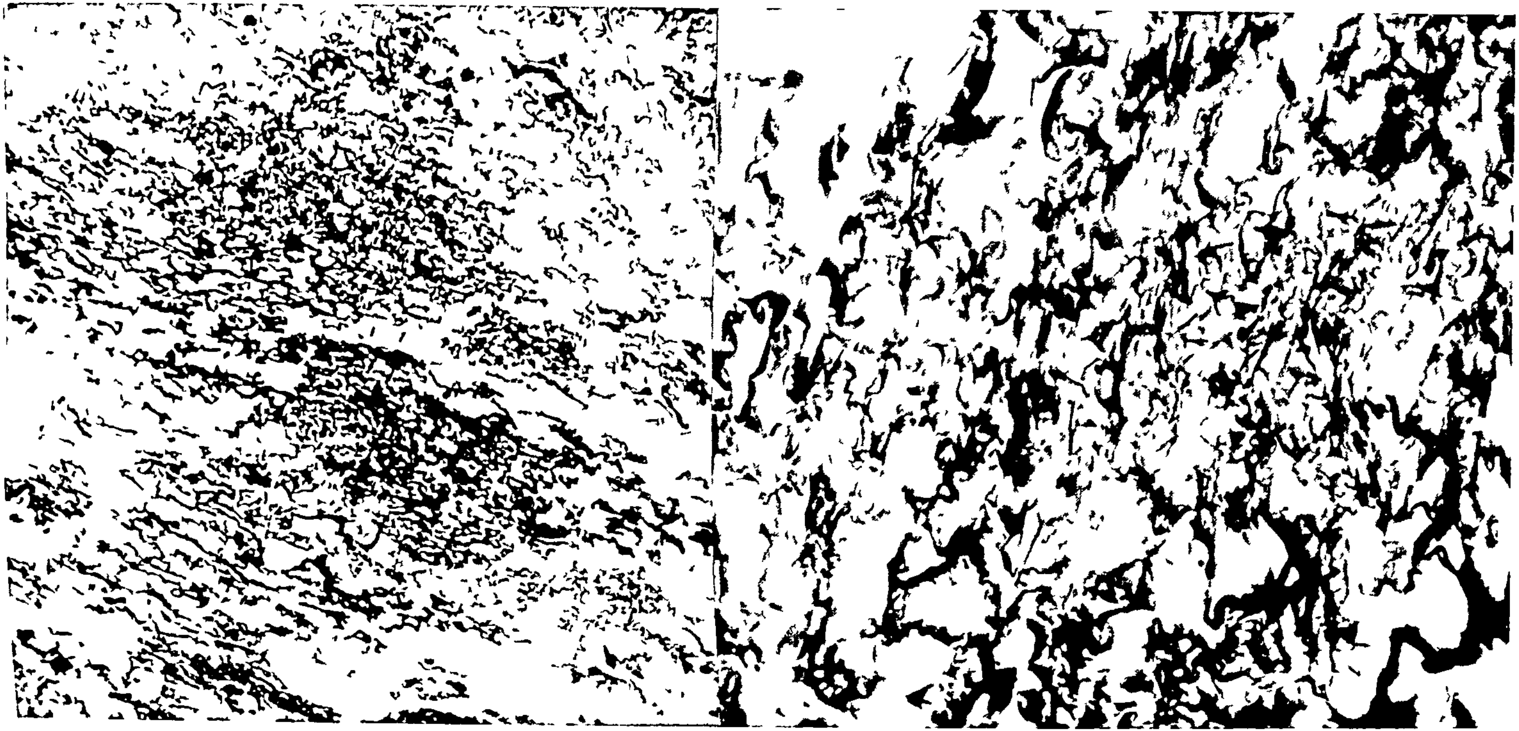

Fig 2 Cross section of decrystallized submaxillary calculus PAS stain A —Magnification × 137 B —Magnification × 180

matrix with diastase prior to the PAS reaction does not appear to diminish the reaction, and hence glycogen is not a prominent component of salivary matrix The matrix shows a tendency to fibrillar and intervening amorphus structure quite similar to matrices of urinary calculi The tendency of the fibrils to *form concentric laminations is evident* (see Fig 3), but to a much less degree than in the majority of urinary

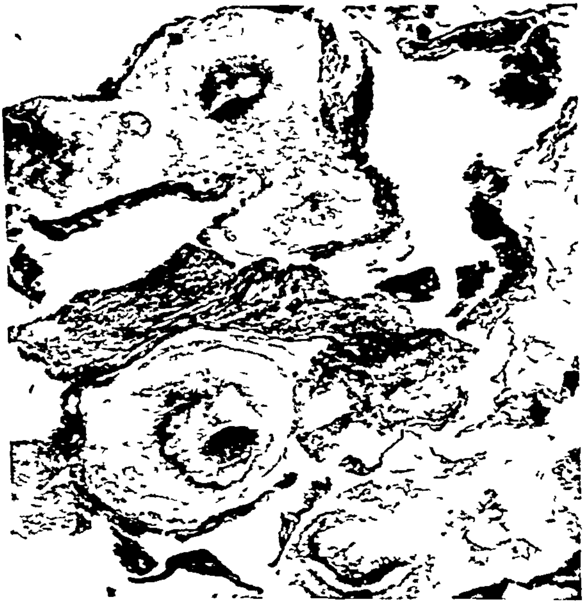

Fig 4 Cross section of decrystallized submaxillary calculus Aqueous toluidine blue stain Magnification × 85

calculi No epithelial or blood cells have been seen in the matrices of salivary calculi

The aqueous toluidine blue gives a uniform orthochromatic (blue) color to the matrix with only rare areas of purplish-red metachromasia (see Fig 3)

The Sudan black stain gave no indication of lipids within the salivary matrices, and extraction of a single pooled sample of matrix revealed no evidence of alcohol-ether soluble material

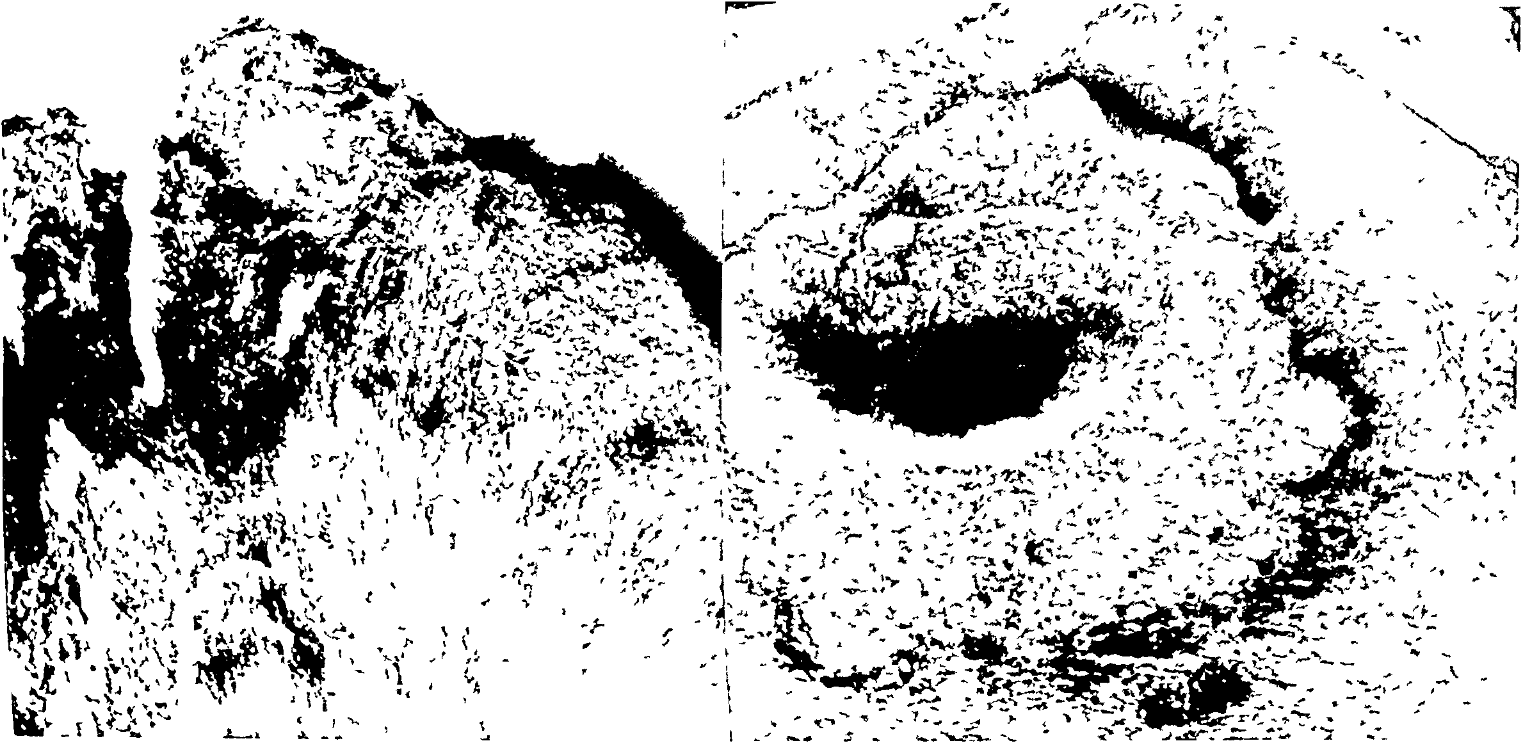

Fig. 3 C—PAS stain magnification × 180 D—Toluidin blue stain magnification × 180

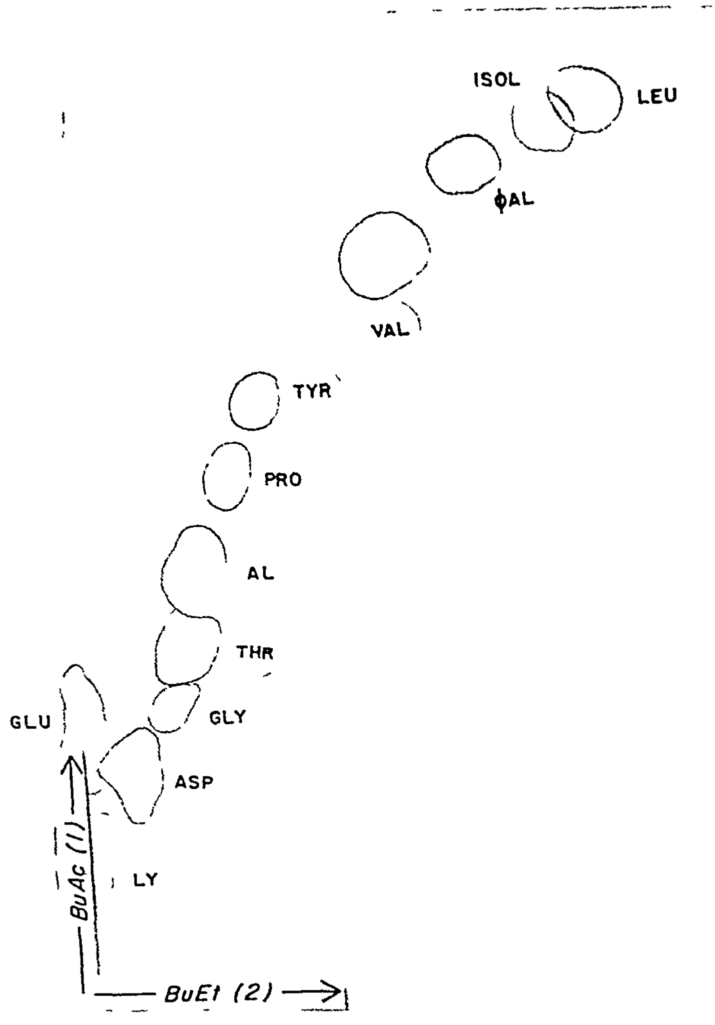

Fig 6 Two dimensional chromatogram of calculous matrix hydrolyzed as preparation in Fig 5 Systems were (1) n-butanol acetic acid water (4 1 5 v/v) and (2) n-butanol ethanol (95 per cent) water (4 1 1 v/v)

TABLE II

AMINO ACIDS IDENTIFIED CHROMATOGRAPHICALLY

α Alanine
Glutamic Acid
Aspartic Acid
Serine
Leucine
Isoleucine
Valine
Phenylalanine
Glycine
Threonine
Lysine
Proline
(Tryptophane)
(Tyrosine)
(Methionine)
(Arginine)

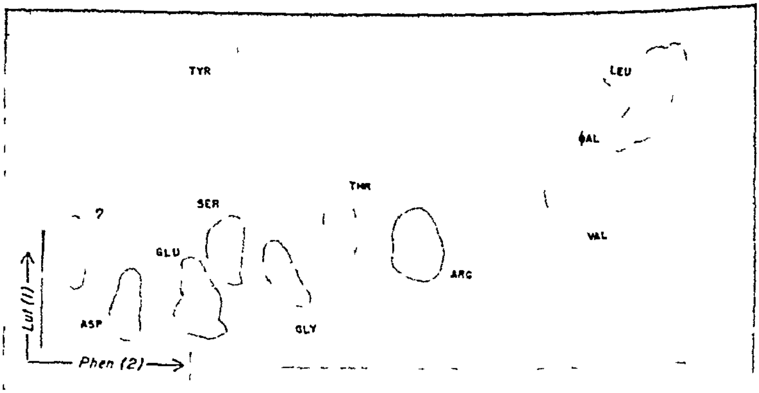

Fig 5 Two dimensional ascending chromatogram of hydrolyzed calculus matrix in the systems (1) 2 6-lutidine water (65 35 v/v) and (2) Phenol water (4 1 v/v) Lyophilized matrix hydrolyzed in 6 N HCl for 24 hours at 90° C

Residue taken up in disodium versenate (0 5 per cent W/v)-isopropanol (10 per cent v/v)-water and centrifuged The supernatant solution was chromatographed in above systems using Whatman No 1 paper for 40 to 50 hours Development by spraying with 0 25 per cent ninhydrin in acetone

The Von Kossa counterstain of the PAS reactive matrix indicated that most of the sites for silver binding (calcium phosphate deposition) were along the margins of the fibrils

COMPOSITIONAL STUDIES OF SALIVARY MATRIX

Matrices from 12 of the larger submaxillary calculi were recovered by lyophilization of the decrystallized calculi

Amino acid components identified chromatographically in the lyophilized matrix are listed in Table II Representative two dimensional chromatograms are depicted in Figs 5 and 6

The known carbohydrate constituents are listed in Table III The lyophilized matrix was found to contain five clearly defined carbohydrates galactose, glucose, mannose, rhamnose and fucose These carbohydrates have been identified in matrices from both urinary and salivary calculi (see Fig 7) In addition to these chromatographically identifiable carbohydrates, deoxypentose and hexosamine, have been identified in salivary matrix by previously described methods[7] Hexuronic acid and "sialic acid" have not been identified in the matrices of salivary or urinary calculi

SUMMARY

The striking similarities in microscopic structure and composition of matrix from urinary and salivary calculi have been summarized Studies of matrix from human fetal bone, gall stones and Mullerian duct calculi have shown distinctly different patterns of carbohydrate and protein content The electrophoretically identifiable components of saliva[6,7] have many similarities to components of the total nondialyzable solids of urine[8,9,10,11]

These observations suggest that calculi form as a result of some abnormality of salivary or urinary mucoid The molecules of mucoid tend to coalesce into a gel and eventually into varying degrees of fibrillar or laminar structures The organic framework thus forms an architectonic function in the deposition of calcigerous crystals The extent to which ion binding activity or epitactic stimulation influence crystalliza-

TABLE III

CARBOHYDRATES OF CALCULOUS MATRIX

Galactose	Hexosamine
Glucose	
Mannose	Deoxypentose
Rhamnose	
Fucose	

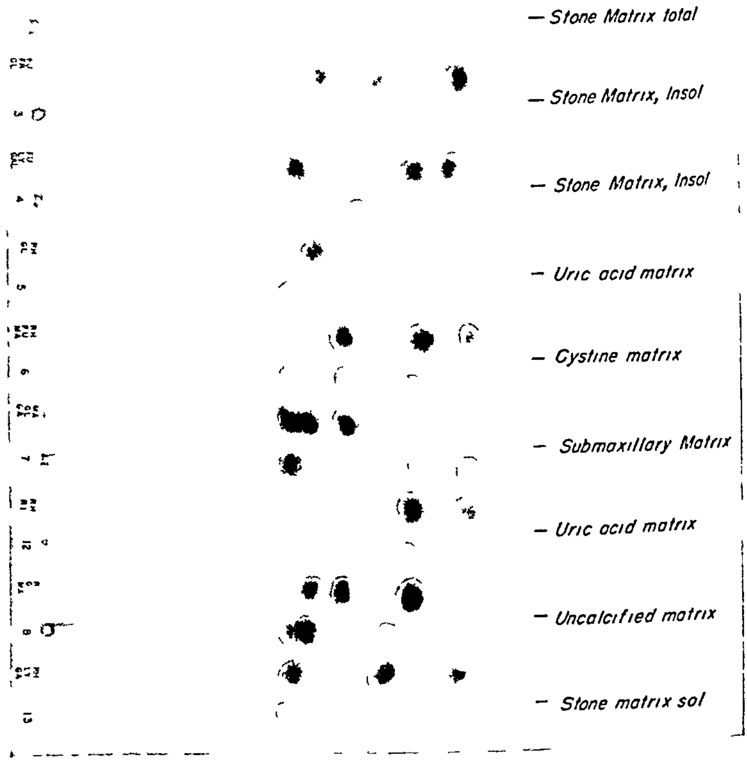

Fig 7 Comparative chromatogram of carbohydrates from matrices of submaxillary calculi urinary calculi and urinary mucoprotein (uromucoid) Lyophilized matrix was subjected to resin hydrolysis for 48 hours (Glegg and Eidinger Anal Chem 26 1365 1954) Triple ascension was made in n-butanol acetic acid water (4 1 5 v/v)

FALSE POSITIVE PERCEPTION DEAFNESS TESTS*

LYLE M SELLERS M D,

Dallas, Tex

In October, 1953, a communication concerning a necessary revision in our concepts of the hearing tests was read by me before the Section on Ophthalmology and Otolaryngology of the Southern Medical Association[1] In this paper, after reviewing the tests of hearing utilizing only the at-threshold tests and pointing out their occasional fallibility, especially those involving bone conduction, the added aid to diagnostic accuracy to be found in the above-threshold tests was considered I said about recruitment, (It is) "a phenomenon appearing in certain cases of perception, or 'nerve' deafness, notably in vascular disturbances of the labyrinth and in presbyacusis In other such cases it does not appear" In other words, I felt secure in the concept that a case of impaired hearing showing a Weber test, in which the fork was not heard when placed to the forehead or when it lateralized to the better hearing ear, a Rinné test showing air conduction equal to or better than bone conduction, with an audiometric drop in bone conduction and a high tone air conduction loss, or an air conduction loss in the middle tone ranges when coupled with recruitment, was a case with positive indications of cochlear impairment

I was jolted out of my complacency when the following case came for consideration

Case No 1 Mrs I C age 64 years presented herself on December 29, 1955 complaining of a closed feeling in her left ear and moderate hearing impairment in that ear since the Thanksgiving just passed The ear disturbance had followed an acute upper respiratory infection Physical examination was negative there being only slight bilateral tympanic membrane retraction No fluid was seen in either middle ear The results of her hearing tests are shown on her audiogram (see Fig 1) *

---

*Read at the Meeting of the Southern Section of the American Laryngological Rhinological and Otological Society Atlanta Ga Jan 23 1959

**All fork* tests were done with Riverbank Laboratories calibrated forks The audiometer used was the Maico E2 and all tests were run in an efficiently sound-treated two-chambered suite

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tion remains at present largely a matter of conjecture There is much evidence that formation of the organic matrix is a prerequisite to calculus formation, and that crystal deposition is a secondary phenomenon The observation that dental calculus tends to deposit in greatest concentration opposite to the orifices of the submaxillary and parotid ducts suggests a similar mechanism for formation of dental and salivary gland calculi

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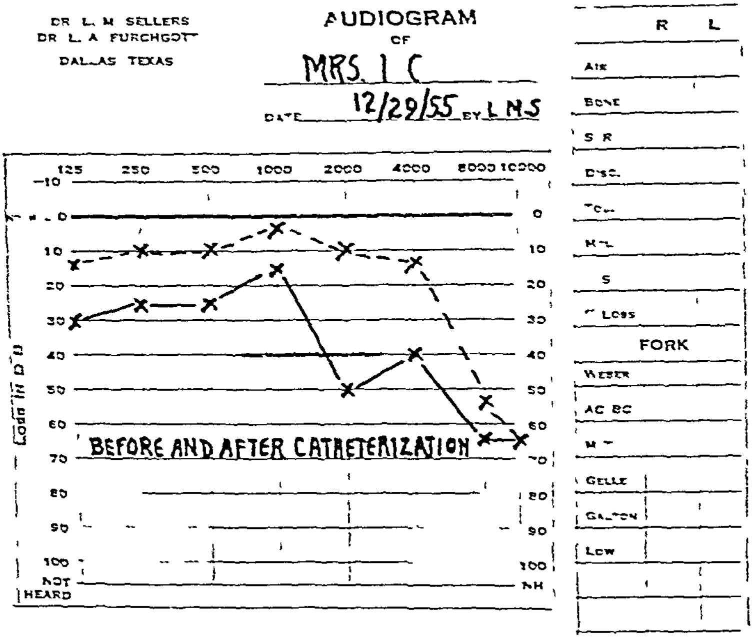
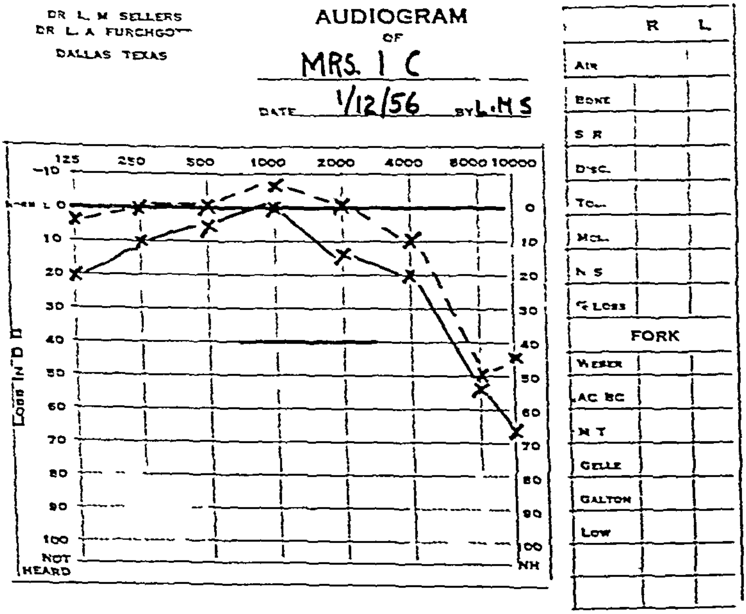

DR L. M SELLERS
DR L. A FURCHGOTT
DALLAS TEXAS

AUDIOGRAM OF MRS. I C
DATE 12/29/55 BY L MS

BEFORE AND AFTER CATHETERIZATION

Fig 2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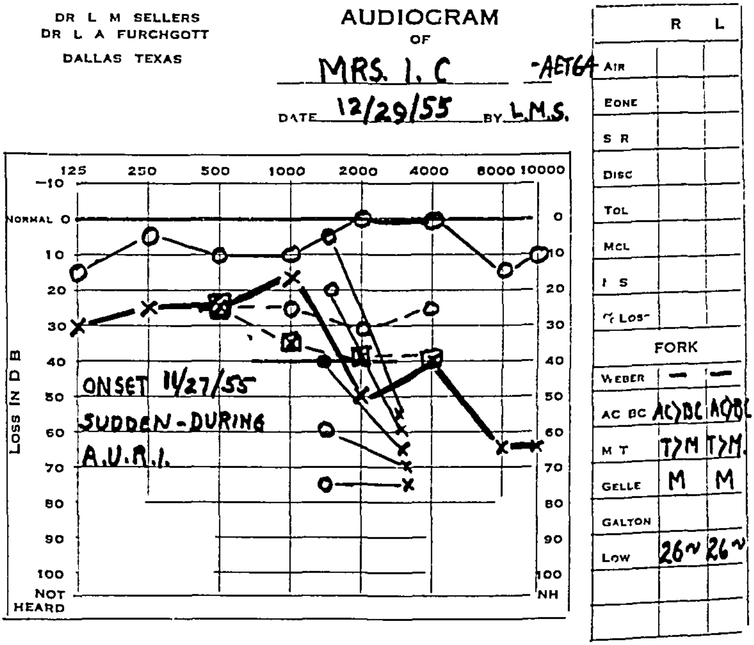
DR L. A FURCHGOTT
DALLAS TEXAS

AUDIOGRAM OF MRS. I C
DATE 1/12/56 BY L.M S

Fig 3



DR L M SELLERS
DR L A FURCHGOTT
DALLAS TEXAS

AUDIOGRAM
OF
MRS. I. C -AETAT 64
DATE 12/29/55 BY L.M.S.

	R	L
AIR		
BONE		
S R		
DISC		
TOL		
MCL		
I S		
% LOSS		
FORK		
WEBER	—	—
AC BC	AC>BC	AC>BC
M T	T>M	T>M
GELLE	M	M
GALTON		
LOW	26~	26~

ONSET 11/27/55
SUDDEN-DURING
A.U.R.I.

Fig 1

Here are present all the criteria for a left cochlear impairment negative physical findings, the air conduction bone conduction relationship unchanged and no raising of the lower tone limit with the forks, an audiogram showing a high tone conduction loss, a corresponding drop in bone conduction and the presence of marked recruitment I was about to tell her the discouraging news that she probably had suffered a post influenzal perceptive lesion when something caused me to do a thing that I had never done before in a case with such findings, actually I do not know why I did it Probably it was done to convince her that I had done everything possible before making an unfavorable diagnosis I catheterized her left eustachian tube The tube apparently was wide open (the test having been done as always, with binaural auscultation) with no obstruction and no sound of rales Her face glowed with surprise and happiness as she said, "That's it' I am all right now"

"Psychotherapy," I thought to myself, "these deafened people always find improvement following any method of treatment," but I repeated her audiogram As shown in Fig 2, it was my turn to be surprised Two weeks later I repeated her left audiogram, which showed further spontaneous improvement Then I catheterized her with the same tubal findings, a repeat audiogram showed even further improvement (see Fig 3)

I considered this to be a freak case and showed copies of the audiograms to several colleagues, who also thought it odd My having made and saved the copies of these audiograms made possible this report she noticed decreased hearing in her left ear with a feeling as of closure of the ear Physical examination showed both tympanic membranes to be normal in appearance There was no visible evidence of fluid in the left middle ear in various head positions but massage with the Siegel otoscope moved the drum head with a sluggish undulatory motion With forks the Weber test was referred to the right or sound side, the air conduction equalled the bone conduction bilaterally, the fork was heard better via the tragus than via the mastoid and the low limit was 26 cps bilaterally The audiogram (see Fig 4) showed essentially normal air

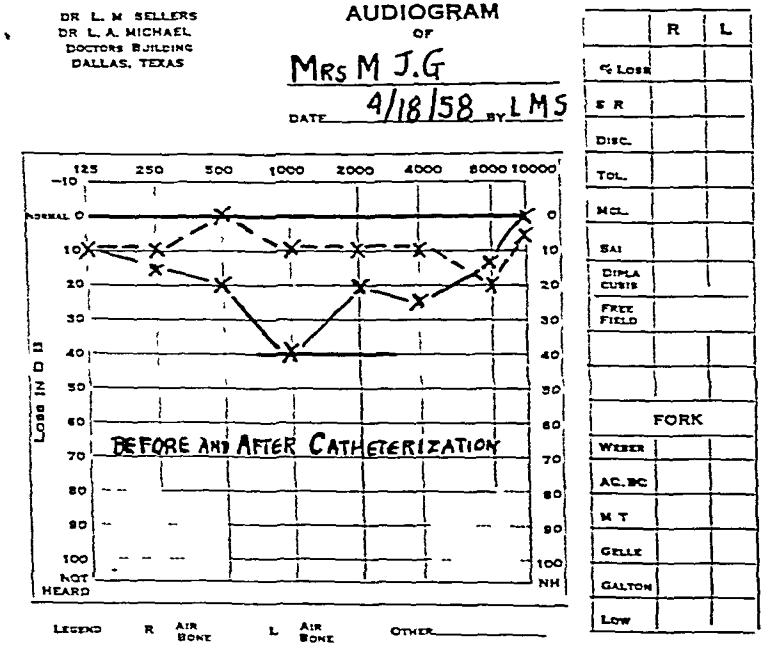


Fig 5

and bone conduction in the right ear There was a mid-range loss in the left ear for both air and bone conduction the air conduction loss being greatest at 1 000 cps where she was recruiting markedly Again all the criteria were present for the diagnosis of cochlear damage

Catheterization of the left tube revealed moderate occlusion with rales and after catheterization fluid with air bubbles was seen in the left middle ear Repeat audiogram (see Fig 5) showed the air conduction to be now essentially normal She was seen and treated twice more and was dismissed on April 28 with her hearing improvement sustained

Case No 3 Miss M G age 47, presented herself July 5 1958 On May 8 she was in an automobile accident with some mild injury to the head Since then her left ear had bothered her with ringing, roaring and some loss of hearing No legal action was pending Physical examination of the ears was normal The fork tests showed the Weber referred to the left side undisturbed air conduction bone conduction and tragus-mastoid

In talking about it with Dr Theodore Walsh, he advanced the speculation that it had been the result of a small droplet of thick mucus lodged in the round window, which was dislodged by the catheterization This apparently answers the puzzle

I noticed several cases during the following year that were similar, but they were placed back in the office files as being merely evidence that unusual cases seem to occur in groups, and so were lost for statistical purposes except as subsequent visits turned them up, because we keep no cross index of diagnoses Some months ago it occurred to me that these scattered cases may constitute a pattern, and I began keeping a separate record of such cases Let us consider a few of them

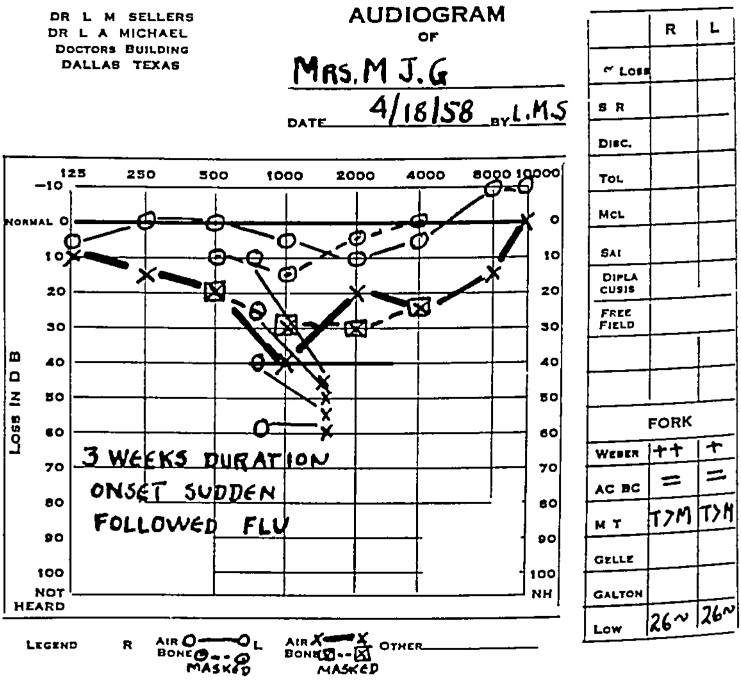
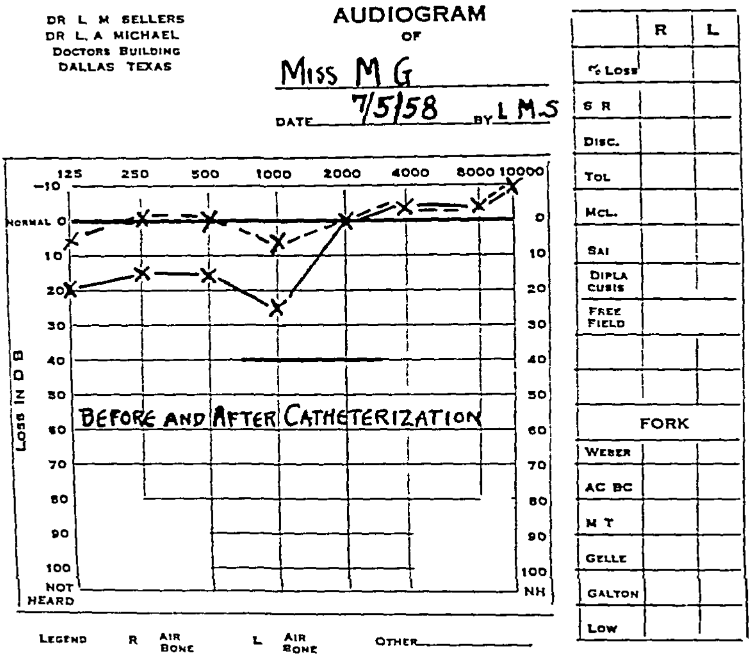


Fig 4

Case No 2 Mrs M J G, age 60 was seen first on April 8 1958 Immediately following a bout with true influenza three weeks previously



DR L M SELLERS
DR L A MICHAEL
DOCTORS BUILDING
DALLAS TEXAS

AUDIOGRAM
OF
Miss M G
DATE 7/5/58 BY L M S

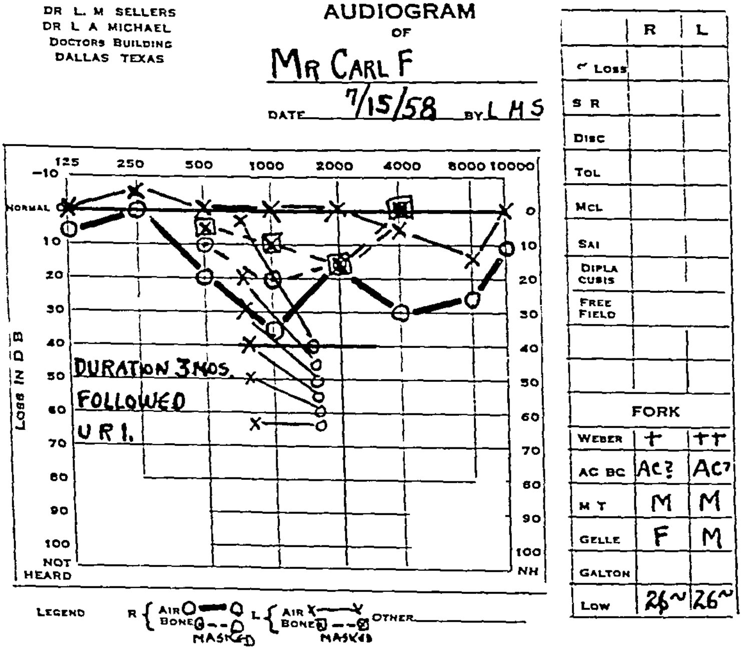
BEFORE AND AFTER CATHETERIZATION

LEGEND R AIR BONE L AIR BONE OTHER

	R	L
% LOSS		
S R		
DISC.		
TOL		
MCL.		
SAI		
DIPLACUSIS		
FREE FIELD		

FORK		
WEBER		
AC BC		
M T		
GELLE		
GALTON		
LOW		

Fig 7



DR L M SELLERS
DR L A MICHAEL
DOCTORS BUILDING
DALLAS TEXAS

AUDIOGRAM
OF
MR CARL F
DATE 7/15/58 BY L H S

DURATION 3 MOS.
FOLLOWED
U R I.

LEGEND R { AIR O━━O BONE O--O MASKED } L { AIR X——X BONE ☒--☒ MASKED } OTHER

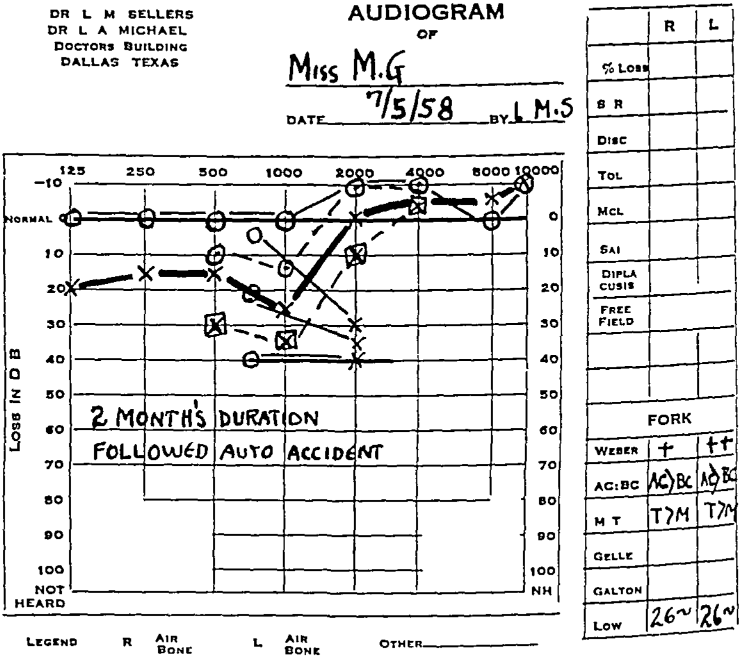
	R	L
% LOSS		
S R		
DISC		
TOL		
MCL		
SAI		
DIPLACUSIS		
FREE FIELD		

FORK		
WEBER	+	++
AC BC	AC?	AC?
M T	M	M
GELLE	F	M
GALTON		
LOW	26~	26~

Fig 8

relationships and the low limit to be 26 cps Her audiogram (see Fig 6) showed essentially normal air and bone conduction curves for the right ear with a left air conduction low and middle tone moderate loss, there being a 25 db loss at 1,000 cps The curve rose sharply to normal at 2 000 cps and above normal at 4,000, 8,000, and 10,000 cps The bone conduction curve for the left ear was 10 to 15 db below the air conduction curve until 4,000 cps where they became identical At 1,000 cps there was marked recruitment Here apparently was a clear case of traumatic cochlear damage that I feel sure would have held up in any court of law had a damage suit been pending

Catheterization of the left tube showed initial occlusion which yielded



	R	L
% Loss		
S R		
Disc		
Tol		
MCL		
SAI		
Diplacusis		
Free Field		
FORK		
Weber	+	++
AC:BC	AC>BC	AC>BC
M T	T>M	T>M
Gelle		
Galton		
Low	26~	26~

Fig 6

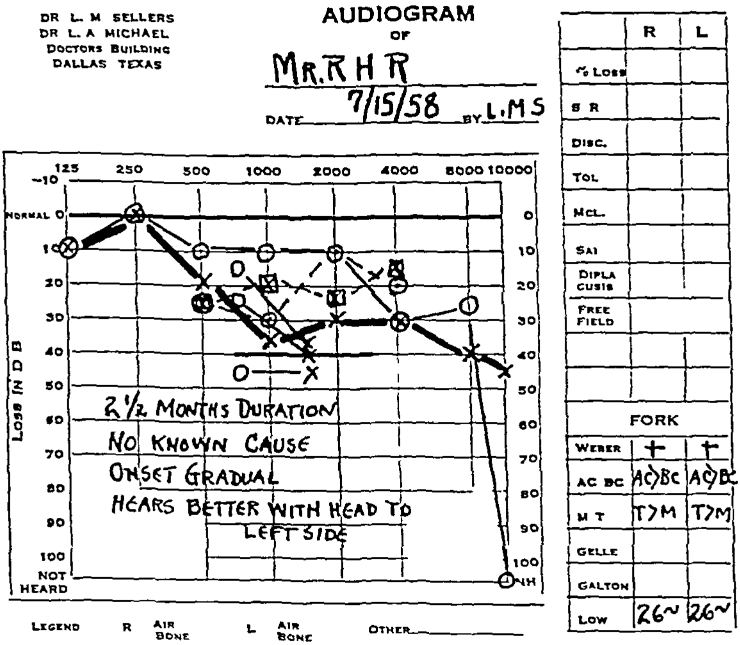
to the air current An audiogram made immediately subsequent to the catheterization presented a normal curve (dash line) as shown in Fig 7 She was seen again in one week, when a loss less than the original loss was present This, too, yielded to catheterization At the third treatment a week later she showed further improvement This progressive improvement has been maintained by biweekly and now triweekly sessions

Case No 4 Mr C F, age 47, was seen first on July 15, 1958 He complained of a loss of hearing in the right ear with a feeling of stoppage His trouble had existed for three months and had followed an acute upper respiratory infection Physical examination revealed slight bilateral tympanic membrane retraction without fluid in the middle ears By the fork tests he referred the Weber to the left (sound) ear, the Rinné test showed the air conduction to be questionably better than the bone conduc-

12 incision again yielded fluid, but much less than on the first occasion His progress since has been uneventful

Case No 5 Mr W M R, age 60, came to us first on July 15, 1958, the same day on which we first saw Case No 4 There was fullness with diminished hearing in the left ear of two and one half months' duration and with no attributable cause He felt better, and he heard better when lying on his left side There was marked retraction of the right tympanic membrane The left tympanic membrane was moderately retracted and a scant amount of fluid, whose level shifted with change of head position, was present

The fork tests showed the Weber to be without lateralization, the Rinné demonstrated air conduction to be greater than bone conduction, hearing by tragus was better than by mastoid and the low limit in both ears was 26 cps The right ear showed audiometrically (see Fig 10) a high tone air conduction loss commensurate with his age, the left ear a middle and high tone loss There was bilateral lowering of the bone conduction threshold curve greater in the right ear at 1 000 cps In the left ear there was marked recruitment at 1 000 cps Catheterization of the left tube revealed moderate occlusion which yielded to gentle pressure with the appearance of bubbles in the middle ear fluid A repeat air conduction audiogram (see Fig 11) showed marked improvement in the middle range the hearing level now equalling that of the right ear Myringotomy followed again by catheterization, produced a profuse dis-



DR L. M SELLERS
DR L. A MICHAEL
DOCTORS BUILDING
DALLAS TEXAS

AUDIOGRAM
OF
Mr. R H R
DATE 7/15/58 BY L.M.S

2½ MONTHS DURATION
NO KNOWN CAUSE
ONSET GRADUAL
HEARS BETTER WITH HEAD TO LEFT SIDE

	R	L
% Loss		
S R		
Disc.		
Tol.		
MCL		
SAI		
Diplacusis		
Free Field		
FORK		
Weber	+	+
AC BC	AC>BC	AC>BC
M T	T>M	T>M
Gelle		
Galton		
Low	26~	26~

Fig 10

tion, hearing by mastoid was greater than by tragus bilaterally, the Gelle test was positive for fixation of the left stapes, and the low limit was 26 cps bilaterally

The audiogram (see Fig 8) was completely normal for the left ear, but revealed a mid tone range loss by air conduction in the right ear, with the greatest loss at 1,000 cps, where there was marked recruitment The bone conduction curve was lowered definitely, but was not lower than the air conduction curve

Catheterization of the right tube disclosed slight occlusion, which opened under moderately light pressure and without rales, but without relief of his feeling of fullness and deafness Recalling Dr Walsh's opinion that this picture could be produced by heavy mucus clinging to the round window, I repeated the catheterization, using increased pressure until the drum head was distended and very slight vertigo occurred A repeat audiogram (see Fig 9) showed a marked rise of the air conduction curve to almost the normal level

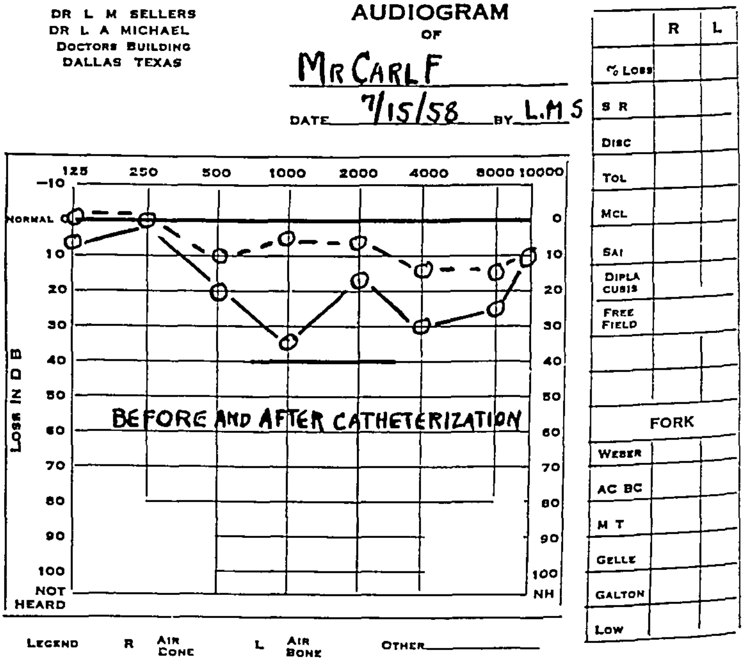
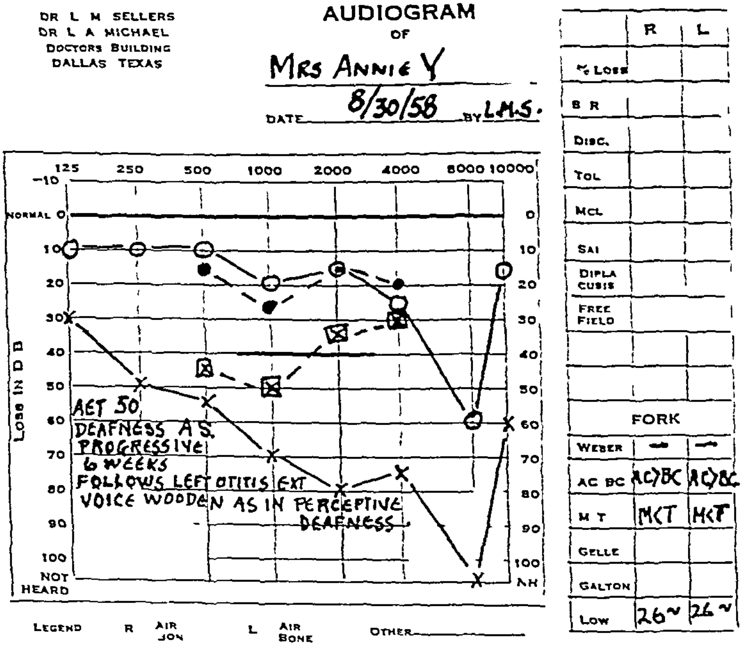


Fig 9

On July 15, there was a recurrence of his symptoms The tube was found to be occluded, and rales were heard when the occlusion yielded, but without relief The drum head was incised, and catheterization was repeated This time a profuse amount of straw colored fluid was blown into the canal On July 24 the drum was healed, and his hearing was essentially normal

On August 18 there was a recurrent tubal occlusion, and on September out with a marked drop to the right, with notching at 8,000 cps that carried the curve out of hearing limits The bone conduction curve, although higher than the air conduction curve, was lowered markedly but rose to the right Because of the marked lowering of the air conduction curve of the left ear loudness balancing was not feasible Fortunately, this omission remedied itself later

Catheterization of the left tube revealed moderate occlusion, which yielded to pressure and without rales There was marked hearing improvement (see Fig 13), relief of the feeling of fullness and complete loss of the wooden quality of the voice



MRS ANNIE Y

DATE 8/30/58 BY LMS.

AET 50

DEAFNESS AS. PROGRESSIVE

6 WEEKS

FOLLOWS LEFT OTITIS EXT

VOICE WOODEN AS IN PERCEPTIVE DEAFNESS.

	R	L
% LOSS		
S R		
DISC.		
TOL		
MCL		
SAI		
DIPLACUSIS		
FREE FIELD		
FORK		
WEBER	→	→
AC BC	AC>BC	AC>BC
M T	M<T	M<T
GELLE		
GALTON		
LOW	26~	26~

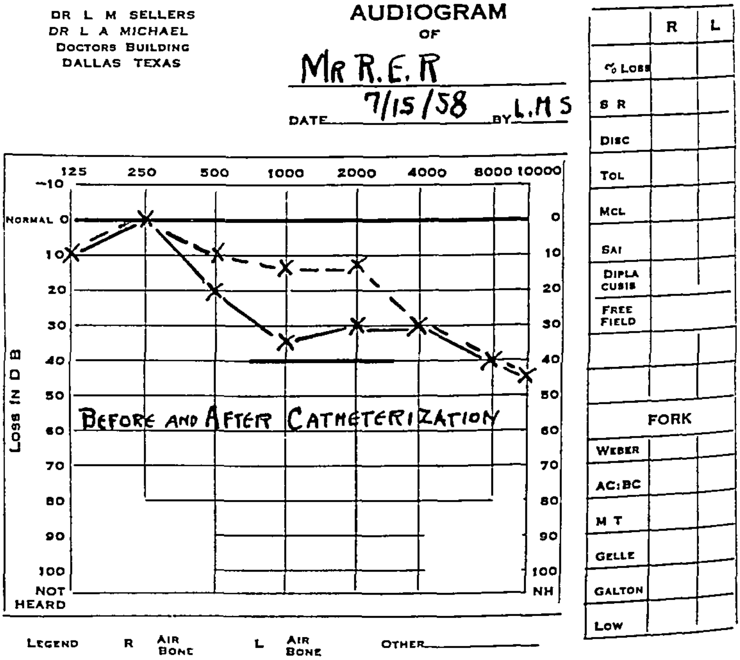
Fig 12

Three days later there was a marked spontaneous improvement which was increased by catheterization (see Fig 13)

On September 8 there was a moderate recurrence of her symptoms and findings, as shown in Fig 14, but this time loudness balance at 4,000 cps was feasible, and it revealed very marked recruitment Catheterization immediately brought her air conduction curve up to approximately that of her right ear Her improvement has been steady, and at the time of this writing there has been no further recurrence

Case No 7 Mr F S, age 42, was first seen on June 3 1957 complaining of hearing loss with tinnitus in the left ear for three months Its onset occurred during an attack of acute rhinitis There was no vertigo With the fork tests the Weber lateralized to the right the Rinné was normal in both ears, and the low limit bilaterally was 26 cps (see Fig 15) charge of yellow fluid The improvement in his hearing level remained the same and he was discharged on July 21 He has been seen subsequently concerning another otolaryngological problem, and his hearing was the same as on July 21 In this case the history and the clinical and audiological pictures substantiate Dr Walsh's proposal that the cochlear syndrome in these cases is produced by occlusion of the round window It will be recalled that the patient stated in his history that turning onto the left side (which by gravity would tend to clear the round window) partially relieved his hearing disability

Case No 6 Mrs A Y , age 54, was seen on August 30 1958, because of severe progressive hearing loss and tinnitus in the left ear Her complaint



MR R.E.R

DATE 7/15/58 BY L.M.S

BEFORE AND AFTER CATHETERIZATION

Fig 11

had been present for six weeks and had followed an infection of the external auditory canal Her voice was characteristic of severe perception deafness, wooden in tone high pitched and very loud

The canals, tympanic membranes and middle ears were quite usual in appearance By fork tests the Weber was heard in neither ear, the Rinné test showed the air conduction to be greater than bone conduction hearing by tragus better than by mastoid, and the lower limit to be 26 cps, all bilaterally (see Fig 12)

The audiometric air conduction curve of the right ear showed a slight tip downward to the right with marked notching to 60 db at 8,000 cps The bone conduction curve approximated that of the air conduction curve The left air conduction curve showed marked lowering through

Audiometrically the right air conduction curve remained at the zero line until 2 000 cps after which point it dropped continuously The bone conduction curve was depressed and roughly followed the air conduction curve The left air conduction curve showed a level depression at 30 db until 2,000 cps, after which it roughly followed the right air conduction curve at a 5 to 15 db lower level The left bone conduction curve was lower than the air conduction curve and roughly followed it Recruitment was present in the left ear at 1 000 cps The tube was widely patent, and no improvement in hearing followed catheterization A final diagnosis of cochlear impairment was made and he was placed on vitamin vasodilators His air conduction curve fluctuated upward and downward as shown by the dash lines on Fig 16 for July 1 1957, and March 4, 1958

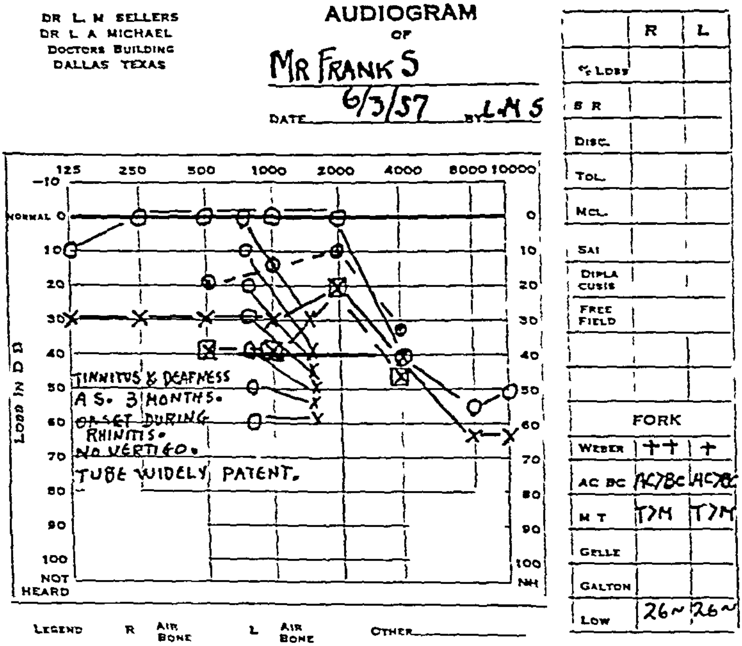


Fig 15

On August 26 1958 he came to the office and stated that his 'ear had popped open yesterday" and that he felt completely relieved His air conduction at this time is indicated by the heavy solid line in Fig 16 This episode could have resulted only from something dislodging itself from some critical area in the middle ear and I can imagine no site other than the round window for this

The cases that we have discussed here are of great importance to all of us in our practice

It has become a habit lately for otologists to look down

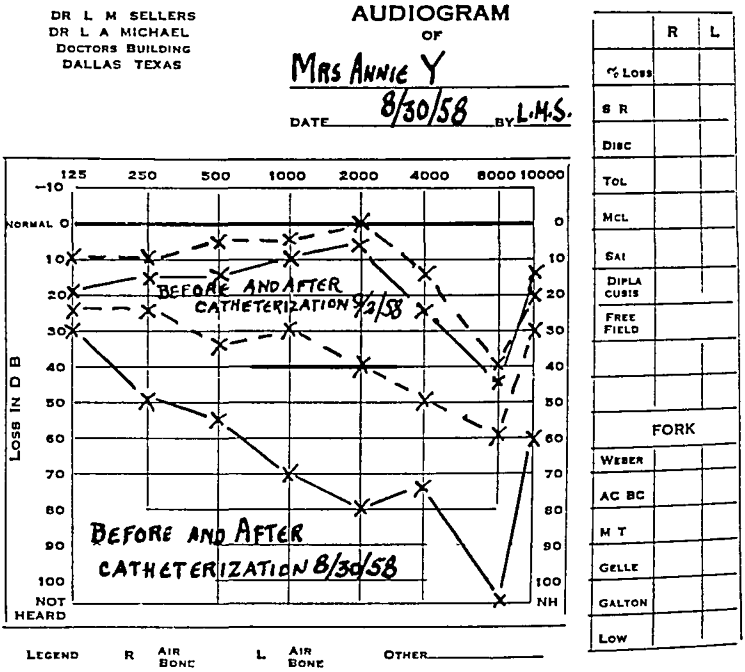

DR L M SELLERS
DR L A MICHAEL
DOCTORS BUILDING
DALLAS TEXAS
AUDIOGRAM
OF
Mrs Annie Y
DATE 8/30/58 BY L.M.S.
125 250 500 1000 2000 4000 8000 10000
-10
NORMAL 0
10 20 30 40 50 60 70 80 90 100
NOT HEARD
NH
LOSS IN D B
BEFORE AND AFTER CATHETERIZATION 9/2/58
BEFORE AND AFTER CATHETERIZATION 8/30/58
R L
% LOSS
S R
DISC
TOL
MCL
SAI
DIPLACUSIS
FREE FIELD
FORK
WEBER
AC BC
M T
GELLE
GALTON
LOW
LEGEND R AIR BONE L AIR BONE OTHER

Fig 13

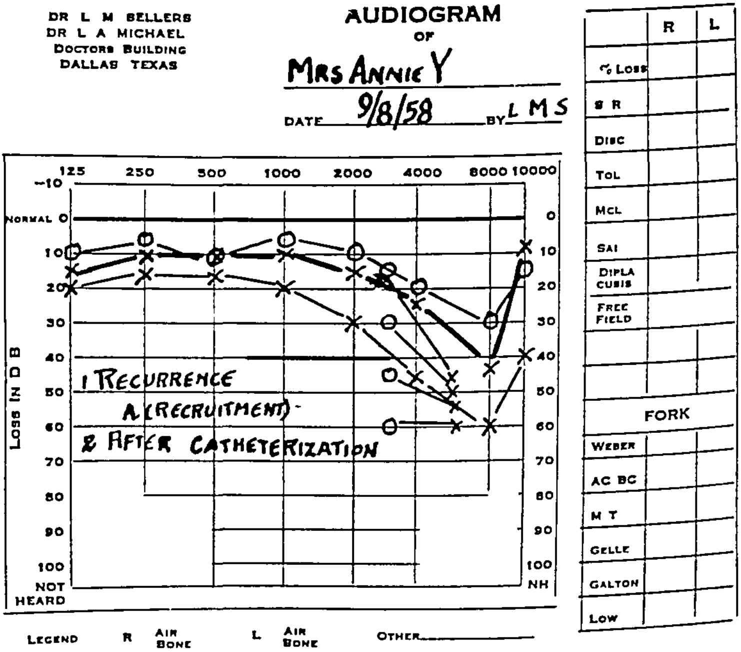
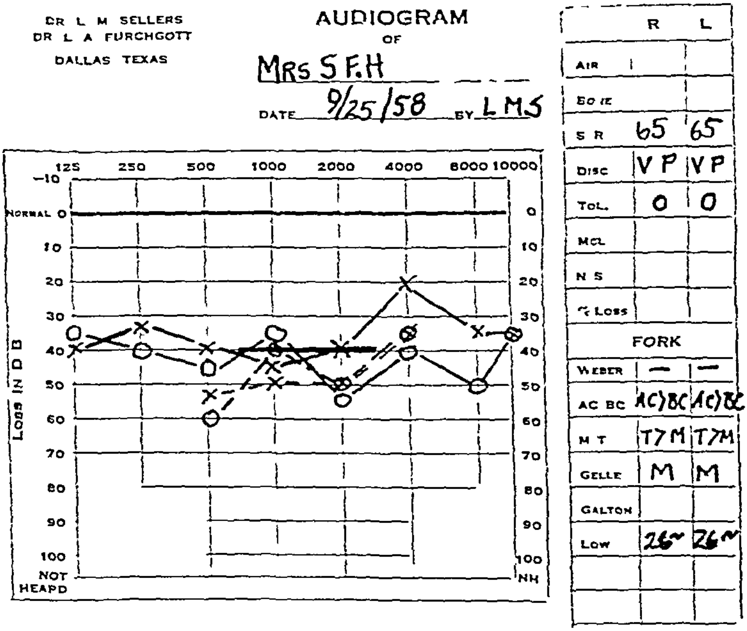

DR L M SELLERS
DR L A MICHAEL
DOCTORS BUILDING
DALLAS TEXAS
AUDIOGRAM
OF
Mrs Annie Y
DATE 9/8/58 BY L M S
125 250 500 1000 2000 4000 8000 10000
-10
NORMAL 0
10 20 30 40 50 60 70 80 90 100
NOT HEARD
NH
LOSS IN D B
1 RECURRENCE
A (RECRUITMENT)
2 AFTER CATHETERIZATION
R L
% LOSS
S R
DISC
TOL
MCL
SAI
DIPLACUSIS
FREE FIELD
FORK
WEBER
AC BC
M T
GELLE
GALTON
LOW
LEGEND R AIR BONE L AIR BONE OTHER

Fig 14

pletely and went on without relief to which they were entitled by Almighty God This thought of misplaced trust is a grave one to bear, even though the error occurred while the best of medical thought and practice of the time was being utilized It is not enough that we did our best Our best simply was not good enough



DR L M SELLERS
DR L A FURCHGOTT
DALLAS TEXAS

AUDIOGRAM
OF
MRS S F.H
DATE 9/25/58 BY LMS

	R	L
AIR		
BONE		
S R	65	65
DISC	VP	VP
TOL.	0	0
MCL		
N S		
% LOSS		
FORK		
WEBER	—	—
AC BC	AC>BC	AC>BC
M T	T7M	T7M
GELLE	M	M
GALTON		
LOW	26~	26~

Fig 17

It now has become the practice in our office to catheterize every case in which unilateral cochlear impairment has been diagnosed This, I am sure, will account for the increasing frequency with which these cases presenting false positive perception deafness tests are being uncovered, and we are looking with only a slightly less jaundiced eye on cases diagnosed as bilateral cochlear impairment

In spite of all that we have just said, less than a fortnight after the foregoing portion of this communication was completed the next case presented itself their noses at catheterization of the eustachian tube, so much so that it has become almost a lost art Those who speak of it may do so at the cost of being considered in the twilight zone of practice This is understandable For all too many men in otology in the recent past it was the *vade mecum* of their practice, and it was used whether indicated or not A reaction following Newton's third law was inevitable I am afraid

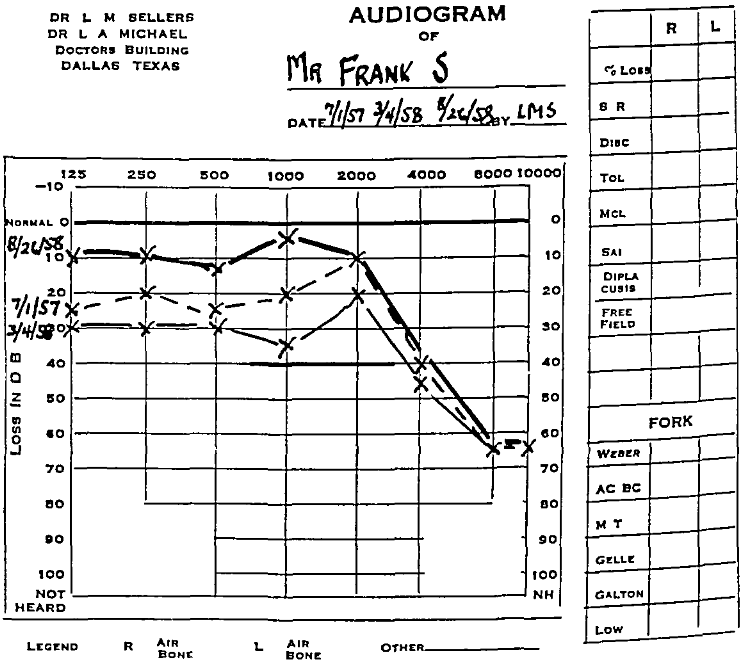


Fig 16

that I have been almost as guilty in this respect as anyone I dread to think of how many poor souls who presented to me the pictures that I have presented to you today (with the exception of those who showed physically the presence of fluid in the middle ear) have been told by me that their difficulty was only possibly amenable to treatment by oral or parenteral medication, and who, when they received no benefit, went to a less "informed" and less "scientific" medico than myself and found relief, or far worse, those who trusted me com-

INJURIES AND SEQUELAE ASSOCIATED WITH ENDOTRACHEAL ANESTHESIA*

J ALLAN FIELDS, M D ,

Fort Lauderdale, Fla

The advantages of the endotracheal method of anesthesia are well known There has, however, been relatively little written about the disadvantages of this procedure which has come to be so eminently useful to us An ever increasing sense of awareness of the possible sequelae of endotracheal anesthesia has been manifest during the past decade Our attention has been particularly stimulated by Flagg,[1] Mintz and Adriani,[2] Moss,[3] Baron and Kohlmoos,[4] and Holinger and Johnston[5] The majority of the work published on this problem has consisted of reports of over one hundred cases of laryngeal granulomata following endotracheal anesthesia

This presentation will deal with the causes, the suggestions for prevention of intubation accidents and sequelae, and a description of the more serious untoward reactions seen during the past twelve years

The undesirable effects of intubation should be divided into those caused by, *1* inexpert use of the laryngoscope, *2* traumatic passage of the endotracheal tube, *3* the presence of the tube itself in the air passages

Many of the sequelae following this method of anesthetic administration are due to faulty knowledge or faulty application of a few basic principles Probably the most frequent is that of the patient's position during laryngoscopy The usual "anesthetist's position" is that of the lambda of the head forming a pivot with the surface of the table, the point of the chin being directed vertically The upper teeth form a fulcrum between the battery handle and spatula of the laryngoscope Using this fulcrum the base of the tongue and

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*Read at the Meeting of the Southern Section of the American Laryngological Rhinological and Otological Society Atlanta Ga Jan 23 1959

Editor s Note This manuscript received in The Laryngoscope Office and accepted for publication Jan 28 1959

Case No 8 Mrs S F H, age 42, was referred on September 25, 1958, by the Vocational Rehabilitation Division of the Texas State Education Agency for whatever help we could give her, as she was about to lose her job because of marked deafness This deafness had been present since the age of 13 years and was of unknown origin Her hearing tests as shown in Fig 17, were typical for perception deafness—the flattened curve for both air and bone conduction with marked raising of both thresholds The fork tests and the speech reception tests were in complete agreement with the pure tone audiogram Only an occasional word could be distinguished at 55 db Raising or lowering the intensity by 5 db lost even that meager hearing gain, however, she was an excellent (self taught) lip reader Catheterization revealed both tubes to be patent, and it did not improve the hearing A diagnosis of perception deafness was made, and she was told as gently as possible the gloomy outlook Fortunately, a friend as a last resort took her to a hearing aid dealer who after making an audiogram, which later proved to be quite similar to the one we had made, empirically tried a bone conduction hearing aid It worked He happened to be a man of high ethics in his calling and he called me by phone to tell me what had happened I had him return her to me for a check of my own findings These were as they were at the first examination with the following exception The speech reception threshold, using the bone conductor to the right mastoid, was found to be at 25 db with excellent discrimination, as she heard practically all words on a spondee list of 50 words With the bone conductor over the left mastoid the left ear showed no improvement in speech reception We simply have no explanation to offer for this bizarre case It remains a challenge and a warning

SUMMARY

A short series of cases has been presented, giving audiological evidence of perception or cochlear deafness, but which proved to have been caused by disturbances in the middle ear conductive mechanism

Warning that these cases occur much more frequently than past experience would suggest is offered

In conclusion, we suggest the possibility that cases Numbered 3, 4 and 5, with middle ear fluid, demonstrated physically which simulated cochlear impairment, but with hearing loss most notable in the middle tone range, may suggest a pattern as an aid in diagnosing the presence of fluid in the middle ear when the fluid is not to be seen on examination

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epiglottis are pried anterioirward allowing a view of the posterior larynx By placing the left thigh across the end of the operating table and resting the patient's head on the thigh, one has achieved a position with which the larynx can be quite easily exposed by merely lifting the base of the tongue and epiglottis

A frequent error in technique is the failure to identify the structures across which the tip of the laryngoscope passes Observation of this error led Moss[3] to state, "ploughing up the pharynx with a laryngoscope in an attempt to dig out an epiglottis from a pool of bloody mucus is one of the least inspiring sights of modern anesthesiology" The anatomy should be recognized step by step beginning with the palate and proceeding in turn to the posterior pharyngeal wall, base of the tongue, tip of the epiglottis, arytenoid eminences and finally the vocal cords During this progression down the pharynx, secretions are best aspirated by a straight rigid tube rather than a soft catheter as the latter is more difficult to manage with one hand

Inexpert use of the laryngoscope has caused a variety of mouth, pharyngeal and laryngeal injuries Myerson[6] states, "All of us have seen broken dentures, loosened or avulsed teeth, and contusions or lacerations in the region of the ascending ramus of the mandible, the tonsillar pillars, the tongue base, the epiglottis or the pharyngeal walls, and last, but by no means least, the structures of the larynx"

Full appreciation of the delicate structures with which the endotracheal tube is in contact will demand of the anesthetist great care and gentleness in the introduction of the tube Many of us have seen lacerations within the nose due to the excessive force applied through a narrow nasal airway Misdirection of the tube so that it does not pass down the lower meatus often leads to the belief that there is inadequate space to accommodate it Much of the bleeding frequently seen during nasal intubation is due to abrading the adenoid, and is usually of little significance Blind intubation, both nasally and orally, should not be practiced except in circumstances where it is inadvisable or impossible to laryngoscope the patient Blind and traumatic passage of the endotracheal tube is credited by some observers as being a factor in the formation of laryngeal granulomata and other sequelae

Case 1 Seen in consultation in 1953 The patient, a young lady, was sent to the Ear, Nose and Throat department for suture of a laceration sustained two hours previously during direct laryngoscopy for the purpose of endotracheal anesthesia The laceration extended into the floor of the mouth on the left side as far anteriorly as the second molar, inferiorly to the angle of the mandible, and posteriorly along the base of the tongue to the level of the epiglottis There was very little bleeding The wound had not been discovered until the operation had been completed, and the patient complained of pain in the area After repair she made an uneventful recovery

COMMENT

Apparently the anesthetist was struggling with a patient insufficiently relaxed Failure to identify the passing anatomy resulted in the technician's becoming lost It is difficult to understand how enough force could be applied to cause such a laceration A smaller tear of the anterior tonsillar pillar caused by the collapse of the head of the operating table while the laryngoscope was in place, has been observed

Case 2 T H, a colored man, aged 52, was scheduled on May 26 1955, for removal of an extremely large goitre Persistent attempts to intubate were unsuccessful and the operation was postponed because of moderate respiratory difficulty Breathing became progressively worse during the day, and in the early evening the patient was in a state of extreme respiratory obstruction An emergency tracheotomy was performed at the bedside The larynx and trachea were found to be displaced 4 cm to the left of the midline causing the tracheal incision to be made beneath the anterior border of the left sternocleidomastoid muscle Aeration improved immediately At midnight during a coughing spell considerable bleeding was initiated A large open thyroid vein was found and tied Mirror laryngoscopy the following day revealed total obscurity of the interior of the larynx by edema and a large hematoma involving the entire left side of the larynx There were several areas of ecchymosis in the pharynx and hypopharynx Laryngeal respiration gradually returned and on June 15 1955, a thyroidectomy was done Final mirror laryngoscopy a month after the accident revealed no trace of the original injuries

COMMENT

This demonstrates the difficulty encountered by a change in anatomic relationships and the resultant injuries caused by too vigorous attempts to force a tube into place It also demonstrates the remarkable healing power of these tissues and their ability to withstand serious injury and yet return to a state of near normality Training, experience and judgment are worth just as much in this field as in any other specialty

Case 3 A white male was scheduled for removal of a lump from the right side of his neck The surgeon's pre operative workup, including mirror laryngoscopy, failed to reveal any abnormality of the larynx or pharynx Endotracheal anesthesia was chosen During the laryngoscopy extensive bleeding from the hypopharynx occurred A fellow anesthesiologist was immediately called to examine the patient He was of the impression that there was a tumor above the right vocal cord Early in the afternoon a laryngologist was asked to see the patient Mirror laryngoscopy revealed extensive edema of the right side of the larynx and pyriform sinus The entire right side of the hypopharynx was obliterated by the swelling Direct laryngoscopy immediately set off rather brisk bleeding, and the procedure was discontinued Ten days later much of the swelling had subsided, and direct laryngoscopy revealed a large fungating tumor of the right pyriform sinus, which was biopsied The pathologist reported squamous cell carcinoma Ten days following this a laryngectomy, right hypopharyngectomy and right radical neck dissection were performed The tumor was highly vascularized and extremely friable

COMMENT

The difficulties encountered during intubation procedures through abnormal or pathological anatomy should be kept in mind The haste often associated with intubating under pentothal adds to the problems of the anesthetist Laryngological consultation in neck tumors should be requested more frequently

Although the immediate untoward results associated with endotracheal anesthesia are due to trauma, this is not entirely true of those seen hours or weeks later Laryngeal edema is seen frequently and is thought to be due to one, or a combination of factors such as an oversize tube, excessive trauma during the passage of the tube through the larynx, friction of the tube against the structures surrounding it, and chemical irritation initiated by the solution used to sterilize the tube

Necrosis of tracheal mucosa has been reported as due to pressure of the inflated cuff Periods of anesthesia in excess of six hours are thought to be necessary in producing sufficient ischemia to bring about the necrosis [5]

The vocal cord polyps occasionally seen are, in all probability, due to the organization of a small submucosal hemorrhage originating during the passage or withdrawal of the tube Excessive voice use during the first few post-anesthetic days may also be a factor

Hematoma within the larynx may vary from slight submucosal hemorrhages along the cord edges to massive collections large enough to obstruct the airway The former are usually due to indelicate introduction of the endotracheal tube, and the latter to unusual and severe trauma, inflicted by the tip of the laryngoscope

The most frequently reported late sequelae of endotracheal anesthesia is the now thoroughly familiar laryngeal granuloma

Case 4 On February 3, 1953, Mrs B F sought relief of her hoarse voice, wheezing respiration, and shortness of breath She had a pelvic operation of long duration three months previously There was no report of the introduction of the endotracheal tube as having been traumatic Immediately on recovery from the anesthetic the patient noticed that her voice was slightly husky, and after four days it became hoarse She was told that this would soon disappear, and on discharge from the hospital several days later it had improved She resumed her usual vocal habits, admitting more than moderate voice use, and in approximately three weeks was again fairly hoarse Often after coughing, phonation would be completely lost for a few seconds There was a constant sensation of phlegm in the larynx Wheezing and moderate shortness of breath gradually became manifest

Mirror examination revealed bilateral 4 mm , rounded, grayish purple pedunculated masses attached to the vocal cords just anterior to the vocal processes They could be blown above the cords by the air blast of coughing and when in the inferior position were almost completely covered during phonation On February 4 1953, direct laryngoscopic removal was performed, using topical anesthesia of pontocaine 1 per cent Microscopic study revealed chronic inflammatory tissue The voice returned to normal, and there had been no recurrence up to the time of the patient's change of residence to another city several months later

COMMENT

It is felt that vocal abuse could have been a prominent factor in the formation of these lesions Several days of voice rest following endotracheal anesthesia, particularly in patients who are bent toward excessive vocalization, may be helpful in preventing this sequela

The etiology of laryngeal granulomata has been the subject of much speculation, as exemplified by the following list of factors thought to have a bearing on their formation

1 The size of the tube [7,12]
2 The solution in which the tube was sterilized [7]
3 Friction between the larynx and the tube [11,12]
4 Blind intubation [7]
5 Febrile upper respiratory infections [12]
6 Elastic pressure of the tight fitting tube [7]
7 Chemical composition of the tube [7]
8 Construction of the advancing tip of the tube [7]
9 Technique of introduction [7,10]
10 The curve of the Magill tube [8,9]
11 Face down position during anesthesia [12]
12 Duration of the anesthetic [12]
13 Post-intubation vocal abuse [12]

TABLE I

INJURIES AND SEQUELAE SEEN DURING PAST TWELVE YEARS

CHILDREN	ADULTS
1 Laryngeal edema necessitating tracheotomy	*1* Severe laceration and separation of base of tongue from lateral pharyngeal wall
2 Laceration of anterior pillar of tonsil	*2* Pinching of upper lip with laceration
3 Avulsion of teeth	*3* Broken denture
4 Broken teeth	*4* Broken teeth
5 Broken orthodontic appliances	*5* Avulsion of teeth
6 Hematoma of vocal cord	*6* Laceration of edentulous gingival margin
7 Ecchymosis of pharynx	*7* Laceration of turbinate
8 Tracheitis	*8* Laceration of adenoid and turbinate
9 Laceration of adenoid	*9* Contusion of mandible
10 Tear of aryepiglottic fold	*10* Laryngeal granulomata, bilateral
11 Laceration of lip	*11* Tracheitis
12 Contusion of gingiva	*12* Laceration of adenoid
	13 Hematoma of vocal cord, extensive
	14 Ecchymosis of pharynx
	15 Vocal cord polyp
	16 Massive edema and hematoma of larynx
	17 Nasal hemorrhage
	18 Severe laceration of a pyriform sinus carcinoma
	19 Laceration of aryepiglottic fold
	20 Functional dysphonia

It is generally agreed that there must be trauma to the thin mucoperichondrium covering the medial aspect of the tip of the arytenoid cartilage The mere passage of a tube through the larynx, even if traumatic, does not necessarily initiate the formation of granuloma. Multiple bronchoscopies or the leaving of a bronchoscope within the airway for many hours has not been reported as causative.

O'Dwyer self-retaining endolaryngeal tubes were used extensively during the years in which diphtheria was prevalent. No case of laryngeal granuloma has been reported following their use. These tubes moved up and down with the larynx during coughing, gagging and swallowing, and thus imparted no frictional trauma to the vocal cords. They did produce untoward reactions but not granulomata. Myerson[13] stated, "The O'Dwyer tubes, when used in too large a size, caused subglottic edema first. If permitted to stay in place a long time, ulceration, perichondritis, necrosis, distortion, and tracheotomy followed. When a proper size tube was used, the patient had no permanent sequelae." Cleif[14] routinely used the largest tube that could be easily introduced, since a smaller size was too readily coughed out.

The use of rubber core molds, or plastic obturators in the treatment of laryngeal injuries has produced none of these lesions, yet these appliances are of large size, and are permitted to remain within the larynx for weeks and months. They move with the larynx and create no friction.

It has been suggested that the curve of the Magill tube may play a prominent part in the etiology. Dwyer, Kronenberg, and Saklad,[8] believe that this is a most important factor in the production of traumatic effects of endotracheal anesthesia, and have substituted a double curved tube.

One of our basic principles in laryngeal treatment has been enforcement of periods of voice rest. After denuding the vocal process by the endotracheal tube, may not the trauma of vocal abuse play a prominent role in the final development of a granuloma? Barton[12] feels that voice rest would reduce the incidence of this lesion.

CONCLUSIONS

It is felt that the more serious injuries associated with endotracheal anesthesia stem from the violation of basic principles of laryngoscopy, and a failure to appreciate the delicate anatomic structures involved Training in laryngoscopy should be stressed among anesthesiologists Some of the causative factors in late sequelae are inherent faults of the endotracheal method of anesthesia It is speculated that removal of the mucosa covering the junction of the membranous vocal cord and the arytenoid are not, in themselves, responsible for granuloma formation, but that there is needed in addition the hammer and anvil action of vocal abuse to forge these lesions

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CORRECTION

In the paper "A Method of Removing a Nasal Hemangiopericytoma" by W Burbank Woodson, published in THE LARYNGOSCOPE for April, 1959, on page 447, the last paragraph should read " a very large growth measuring 2.5x1.7x1.3 cm was removed ."

ADENOIDS, TONSILS, AND TWO DECADES OF CHEMO-ANTIBIOTIC THERAPY *†

PETER N PASTORE, M D ,

Richmond, Va

As is customary in the preparation of any medical report, some of the literature dealing with the tonsil and adenoid problem in recent years was reviewed Boies[1] (1948) noted that from "1942 to 1946 inclusive, there has been an average of 100 papers per year concerning tonsils, listed in the *Quarterly Cumulative Index*, and this in spite of the war years when medical literature was less voluminous than in ordinary times "

Interest in the subject has not diminished in the past ten years Various aspects of the matter, such as pre-operative medication (Rendall) , pre-operative management (Jonkees) , the use of vitamin K (King) , the internists' viewpoint (Badger) , general aspects (Eley) , the relation of hearing (Hoople) , stress on more complete removal (Meltzer) , the anatomy and histology of Rosenmueller's fossa (Reeves and Brill) , the complications and their management (Work), and mortalities and morbidity (Cummings), were all noted by Wishart,[2] et al in a review of the literature (1954) Newer concepts concerning the preventive influence of tonsilloadenoidectomy on the common cold are reviewed by Hollender,[3] who concludes "No causal relationship between the pharyngeal lymphoid structures and the common cold (or other respiratory tract diseases) can logically be considered unless the existing tonsillar disease falls in the category of so-called focal chronic tonsillitis " The specific role and problems *of* the adenoid are discussed by Senturia,[4] who stresses the importance of the complete inspection of the nasopharynx during operation McGovern[5] reviews the advantages of endotracheal

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*Read at the Meeting of the Southern Section of the American Laryngological Rhinological and Otological Society Atlanta Ga Jan 23 1959

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anesthesia and notes that the introduction of the Salk vaccine has probably altered the importance of the much-debated association of tonsillectomy and poliomyelitis

Johnston and Watkins[6] (1954) felt that the decision to remove tonsils and adenoids has been too conservative for the past 30 years They studied 598 children following tonsil and adenoid removal One hundred twelve were between the ages of 1 and 4 years, 331 were between the ages of 5 and 7 years, and 155 were between the ages of 8 and 14 years They noted a reduction in ear infections, decrease in abdominal pain referable to chronic infection, and fewer attacks of bronchitis Patients with sinusitis (13 out of 28), and asthma (three out of 22), showed least improvement after operation The period or duration of follow-up studies was not clear They concluded that tonsillectomy and adenoidectomy remains a highly-beneficial procedure in the properly selected cases

There appeared to be a surprising lack of papers related specifically to the use of antimicrobials and tonsil-adenoidectomy Orzac[7] studied 500 children 2 to 12 years old, subjected to tonsil and adenoidectomy in 1954 and 1955 Pre-operative Adrenosem, one mg three times a day, and a mixture of benzathine penicillin and triple sulfonamides, one teaspoonful three times a day, was given for seven days At operation, one cc of Adrenosem and one cc procaine penicillin were administered intramuscularly, and repeated two hours after completion of surgery On discharge from the hospital, benzathine penicillin-triple sulfonamide mixture with codein, one teaspoonful four times a day, was continued for six days Three hundred patients, as controls, received no medication before or after surgery

"Records were kept on each patient concerning the occurrence of *1* primary and secondary hemorrhage, *2* postoperative infections as determined by clinical examination and evidence of undue elevation of temperature, and *3* postoperative pain as measured by the number of telephone calls from parents and questioning of the parent and child in the postoperative period

"Primary hemorrhage occurred in 1 7 per cent, and secondary hemorrhage in 1 per cent of the 300 control patients, but in none of the 500 children who received preoperative and postoperative medical treatment

"Postoperative infections retarded convalescence in 13 (4 4 per cent) of the 300 unmedicated controls but in only seven (1 4 per cent) of the 500 treated children

"Three of the treated patients had catarrhal acute otitis media, three pharyngitis with adenitis, and one had bronchopneumonia. Viral gastroenteritis developed after operation in another patient in this group but was not counted a true postoperative complication since three family contacts had become ill with the disease the day before the child was operated upon.

"In the unmedicated group otitis media occurred in seven patients, the acute catarrhal form in six and purulent acute in one. Two had bronchopneumonia, three had pharyngitis with cervical adenitis and one had cystitis.

"Postoperative pain severe enough to warrant one or more phone calls from the parents for additional treatment was three times as frequent for the controls as for the medicated patients."

Riggs[8] indicated that pre- and postoperative penicillin should be considered, but not given unless definitely indicated for protection, and that "sulfonamides and other antibiotics pre- and postoperatively may be justified."

A brief but concise report, with special reference to the allergic implications on respiratory symptoms and the influence of tonsil and adenoidectomy is that of Clein[9] (1952), who summarized: "The operation for removal of tonsils and adenoids should be performed for adequate indications in any child whom the physician feels will be benefited by this procedure. Most failures are due to the fact that similar symptoms of allergic etiology are overlooked. Correct diagnosis of the allergic disease, followed by thorough specific treatment will often prevent this operation, as well as certain common complications." He also refers to the important study of Kaiser[10] (1940), who wrote on the significance of the tonsils in the development of the child.

The stimulus for the following comments evolved from the clinical impression gained during the past few years that many children are being referred for tonsil and adenoidectomy at a very early age. The history invariably reveals one or more of the following: *1.* Recurrent attacks of tonsillitis and adenoiditis, *2.* repeated attacks of tonsil and adenoiditis with associated otitis media, *3.* clinical indications of sensitivity to one or more chemo-antibiotic agents, *4.* decreased interval of freedom from upper respiratory tract infections involving the tonsils and adenoids, *5.* definite resistance to the beneficial effects of chemo-antibiotic and medical therapy, *6.* frustrated parents or physicians, faced with the recurrently ill or irritable child, necessary drug bills, medical fees, sleepless nights, and restraint of adult social activity All patients are physician referred

Specifically, this study was undertaken to *1* determine, if possible, whether these observations were unique on a local basis or indications of a national trend, *2* compare the age levels for the removal of tonsils and adenoids before the introduction of chemo-antibiotics with the present, *3* determine, if possible, the role of chemo-antibiotic agents at the time of tonsil and adenoidectomy, *4* obtain some idea as to the present indications for the operation, and *5* observe the effect of pre and postoperative treatment with chemo-antibiotics The results of a study of the latter (No 5) will form the basis of a future report

After much thought and investigation, it was found that, due to the method of keeping physicians' and hospital records, introduction of new hospitals, and many other factors, no reliable data (local) in the period prior to 1936 (prechemo antibiotic period) could be assembled for comparison purposes

This discovery led to the development of a short sampling questionnaire, which was mailed to at least two or more active otolaryngologists, aged 50 years or over, in each State of the Union Complete returns numbered 101 One of these was eliminated to simplify results The findings are summarized as follows

Question No 1

Is it your impression that in general there has been a change in the age level for tonsil and adenoid operations during the past ten years (as compared to the period 1928 through 1938)?

TABLE I

Forty six replied NO, Fifty four replied YES

Degree of Change	Lowered	Increased
1 year	7	11
2 years	11	7
3 years	12	6
	30	24

None of the above were supported by statistical studies but were rendered as clinical impressions

A more definite evaluation was submitted by Simonton[11] comparing the age and number of operations for the years 1935 and 1957

1935—Age	Number	1957—Age	Number
2	13	2	26
3	10	3	30
4	19	4	41
5	15	5	47
6	19	6	46
7	22	7	36
8	13	8	21
	111		247

Question No 2

Number in order of your impression the three most frequent precipitating factors or indications leading to tonsil and adenoidectomy in the age zero to 10 years

The answers were as follows *First*, multiple attacks of primary tonsil and adenoiditis, 80, *second*, repeated attacks of early otitis media, 62, *third*, obstruction to breathing, 30, *fourth*, reduced hearing (not acute), 25, *fifth*, repeated attacks of resistant otitis media, 13, and 4 each for persistant cervical noditis, resistance to the benefits of chemo-antibiotics, common cold, and focal factors Seven listed a single miscellaneous condition

Question No. 3

Do you prescribe chemo-antibiotics routinely?

TABLE II

Before Operation		After Operation
80	None	62
9	1 day	16
3	2 days	8
8	3 days or longer	6
	7 days or longer	8

Question No 4

List the two complications noted most frequently within the first ten days after tonsil and adenoidectomy

Bleeding within the first 24 hours after operation was listed by 40, and after four days or during the slough period by 30. Thirteen replies specified the adenoid region. Infection (not classified and presumably of the postoperative sites) was the second most frequently noted by eight. Among the postoperative symptoms and conditions noted were sore throat, otolgia, vomiting, fever, dehydration, anorexia, otitis media, upper respiratory-tract infection, and worried mothers, in the order mentioned. None indicated the relation of antimicrobials to the complications or symptoms.

The results of the questionnaire are suggestive of a slight trend to an earlier age for the operation. To determine any possible correlation at the local level, we then reviewed the ages of all patients having undergone tonsil and adenoid operations and performed by Operator A at one hospital during the seven-year period 1952-1958, inclusive. The findings are noted in the following:

TABLE III

Age	1952	1953	1954	1955	1956	1957	1958	Total
0 1			1	1	1	1	2	6
1	1	1		1	5	1	3	12
2	24	20	13	18	25	20	31	151
3	40	23	34	16	24	32	39	208
4	32	29	32	15	35	45	42	230
5	38	35	36	15	19	37	50	230
6	19	42	21	15	31	45	38	211
	154	150	137	81	140	181	205	1018

TABLE IV

Age	1952	1953	1954	1955	1956	1957	1958	Total
7	5	20	21	12	26	19	28	131
8	5	7	10	5	14	16	15	72
9	6	3	5	3	13	13	16	59
10	1	3	4	3	8	5	5	29
11	1	3	1		7	6	5	23
12		2	1	1	3	1	1	9
	18	38	42	24	71	60	70	323

In Table III, it will be observed that the youngest patients, less than one year old, totaled 6, in the 1-to-2-year-old period,

TABLE V

Age	1952	1953	1954	1955	1956	1957	1958	Total
13		2	3		5	1	4	15
14			3				2	5
15			1	1	2		3	7
16	1	1			1			3
17							1	1
18			1		2	3	2	8
19	1	1			1			3
	2	4	8	1	11	4	12	42

TABLE VI

Age	1952	1953	1954	1955	1956	1957	1958	Total
0 6	154	150	137	81	140	181	205	1048
7 12	18	38	42	24	71	60	70	323
13 19	2	4	8	1	11	4	12	42
20 or older	6	10	11	3	10	9	7	56
Total	180	202	198	109	232	254	294	1469

there were 12, in the 2-to-3-year-old period there were 151, and the majority, in about equal distribution, in the 3-through-6-year age group

Table No 4 shows a marked decrease in the number of operations performed after age 7 years The ratio of operations for both tonsil and adenoidectomy or tonsillectomy alone, is about the same for the age group from 13 years through 19 years when compared to all ages from 20 years and above

From these results, it can be noted that the majority of tonsil and adenoid operations are performed in the age period from 2 through 7 years, and the period between 3 years and 6 years represents the greatest concentration period for the operation in this series

FACTORS CONTRIBUTING TO THE OPERATION AT AN EARLY AGE

Indications

It was of interest to note that the indications in our group followed very closely those of the questionnaire group Every patient was physician referred, and presumably a medical therapy failure A close review of the group (254) undergoing surgery in 1957 showed that primary tonsil and adenoiditis was responsible for the operation in 69 per cent, tonsil and adenoiditis with history of colds and otitis media and with or without hearing impairment, 26 per cent, and all other causes 5 per cent All of the patients under age 12 years had persistent cervical noditis, and the majority had a history of decreased effectiveness of chemo-antibiotic therapy with each succeeding attack

Anesthesia

The introduction of endotracheal tubing by the experienced anesthetist team, contributing to a safer method of anesthesia administration, is, in our opinion, a major factor of importance in permitting a safe tonsil and adenoid operation at any age, but particularly in young children. This encourages the referring physician and the parents to seek or consent to an early operation

Control of Bleeding

This, in our opinion, is (next to safe anesthesia) the most important factor Multiple factors are responsible for excessive bleeding With careful preparation, this phase can be minimized by *1* having the patient at his best physical state, *2* minimal degree of infectious state possible, *3* control of bleeding at the time of surgery, and *4* the use of chemo-antibiotic therapy pre- and postoperatively, as indicated on an individual basis

Rhoads, et al[1-] stated that "prolonged antibiotic therapy not followed by extirpation of the tonsils may be serious, even if the micro-organisms that were the original objects of the antibacterial attack are temporarily eliminated" Their summary is worth noting

> Blood cultures taken just after tonsillectomy were positive in 28 3 per cent of a group of 68 patients who received no antibiotic therapy prior to tonsillectomy The incidence of bacteria was reduced to 5 9 per cent in a group of 20 subjects who received penicillin in a daily dose of 600,000 to 800,000 units intramuscularly for four to ten days prior to tonsillectomy The incidence of bacteria in a group of 29 patients who received 600 000 to 800,000 unit doses (half this dose for children) of procaine penicillin 12 to 18 hours and one hour prior to tonsillectomy or in a small group (seven) of patients receiving 900,000 to 1,200,000 units orally daily for

five to seven days prior to operation was not reduced below that of the control group Beta hemolytic streptococci were obtained from blood cultures four times, pneumococci once, Alpha hemolytic streptococci (green forming) or Gamma anhemolytic streptococci 28 times and a combination of Beta hemolytic streptococci and Gamma anhemolytic streptococci twice The need for several days preoperative treatment with penicillin to prevent post-tonsillectomy bacteremia is obvious

> In the control series of 68 patients who had no antibiotic treatment immediately preceding tonsillectomy, Beta hemolytic streptococci were present in 57 4 per cent of the cultures of the excised tonsils although these micro organisms were found in only 28 26 per cent of throat cultures taken just before the operation Among patients receiving penicillin in single doses only the day before and the day of tonsillectomy, 31 03 per cent had Beta hemolytic streptococci in the excised tonsils, although these micro-organisms were not present in the throat cultures taken just before tonsillectomy Beta hemolytic streptococci were found only once in the cultures from the excised tonsils of persons receiving penicillin intramuscularly each day for four to ten days prior to tonsillectomy Most of the gram positive micro organisms except micrococci and Gaffkya tetragenus were greatly reduced in number by penicillin administered intramuscularly, but gram positive micro organisms, such as Klebsiella pneumoniae, Aerobacter aerogenes, and Escherichia coli, were found in increased numbers in cultures from the throats and excised tonsils of these subjects

SUMMARY

Accurate statistics for comparison of adenotonsillectomy age levels before and after the introduction of chemo-antibiotics (1936) are not readily available

Chemotherapy and antibiotics apparently have not eliminated the need for the operation below the age of seven years

The *use in early infancy* of chemo-antibiotic therapy to help control the systematic spread of infection and reduce the complications of cold and tonsil-adenoid infections

The apparent ineffectiveness of chemo-antibiotics when used repeatedly.

The apparent lack of immunity of many young children to recurring attacks of tonsil-adenoid infection with or without colds

The value of pre- and postoperative anti-microbials

Improved techniques for safe anesthesia, public knowledge of medical facts, and public acceptance of hospitalization care

The above, collectively, are some of the factors contributing to adenotonsillectomy at an early age

1200 E Broad St

Medical definitions

Antibiotic—1 Destructive of life 2 Pertaining to or characterized by antibiosis The term antibiotics is given to antibacterial substances of biologic origin They are derived from bacteria (pyocyanase pyocanin tyrothricin) from actinomyces (actinomycetin actinomycin, streptothricin streptomycin), from molds and fungi (penicillin citrinin gliotoxin fumigatin, fumigacin, claviformin flavicin flavicidin and others) from natural substances other than micro-organisms (lysozyme chlorellin canavalin allicin)

Chemotherapy—The treatment of disease by administering chemicals which affect the causative organism unfavorably but do not injure the patient

COURS DE TECHNIQUE AUDIOMETRIQUE

The Faculty of Medicine, Paris France, will hold a Course in Audiometry, October 12-18, 1959, under the chairmanship of Prof M Aubry of the Clinic of Oto-Rhino-Laryngology The tentative program includes lectures on the scientific fundamentals, the technique of audiometry, discussions of the results and problems of interpretation, and round table discussions Professor Aubry will be assisted by MM les Professeurs Agreges J J Debain and R Maduro, les Doctears P Aboulker, J Bouche, P Clerc, H Henrot, R Maspetion, J Pialoux, J Bouchet, M Burgeat, L Chevance, P-L Klotz, P Robert, B Vallancien, Mme S Borel-Maisonny, M le Professeur A Didier, MM R Chocholle, J-E Fournier, R Lehmann and A Molles The complete program will be ready in June, 1959 For further details write Secretariet Service Oto-Rhino-Laryngologique Pavillon Isambert, Hospital Lariboisiere 2 Rue Ambrose-Pare, Paris 10°), France

THE LYMPHOID TISSUE OF THE NASOPHARYNX [*][†]

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Although the nasopharynx is no longer the neglected structure it was charged to be a few decades ago, current knowledge concerning the role of its lymphoid tissue remains vague This intricate type of tissue is not restricted to the postnasal space, however, masses of various proportions being scattered normally in other areas of the body Because of the structural similarity of these widely strewn tissue masses, the idea of regarding their total aggregation as a single functioning organ is not without a logical basis Here we are concerned only with the lymphoid tissue of the nasopharynx (see Fig 1) The relationship of this tissue to its own space, to other parts of Waldeyer's ring (see Fig 2), and to the body as a whole provides a problem of vast clinical significance

In recent years scholarly articles have been contributed on the subject Research has ranged from fundamental histopathologic studies to precise observations on the effects of hormonal drugs Through these diversified investigations new ramifications are constantly being exposed Although it is realized that many aspects of the overall problem of lymphoid tissue still need to be clarified, understanding of some of its phases has been removed from the realm of speculation

DEFINITION AND FUNCTION

Lymphoid tissue cannot be defined logically without reference to the lymphoid organs According to Clark,[1] these consist of mere irregular accumulations of lymphoid cells, termed lymphoid infiltrations, and are found in mucous mem-

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[*] Read at the Meeting of the Southern Section The American Laryngological Rhinological and Otological Society, Inc Atlanta, Ga Jan 23 1959

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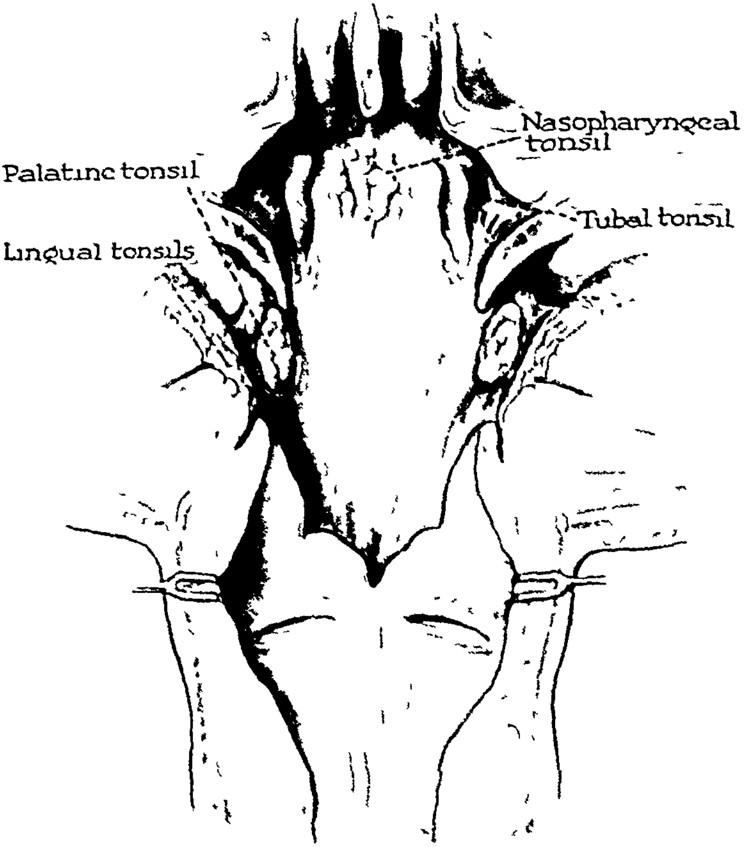

Fig 2 Lymphatic ring of Waldeyer the pharyngeal tonsil and the other lymphatic structures

elements In their recent book, Yoffey and Courtice[a] defined lymphoid tissue as "any tissue consisting predominantly of lymphocytes, such as lymph nodes, tonsils, appendix, and intestinal nodules the lymphocytes in lymphoid tissue are usually intermingled with other elements, to which they may be either functionally or genetically related"

As concerns the lymphatic system, it may be described as a type of circulatory system, an accessory to the venous system—

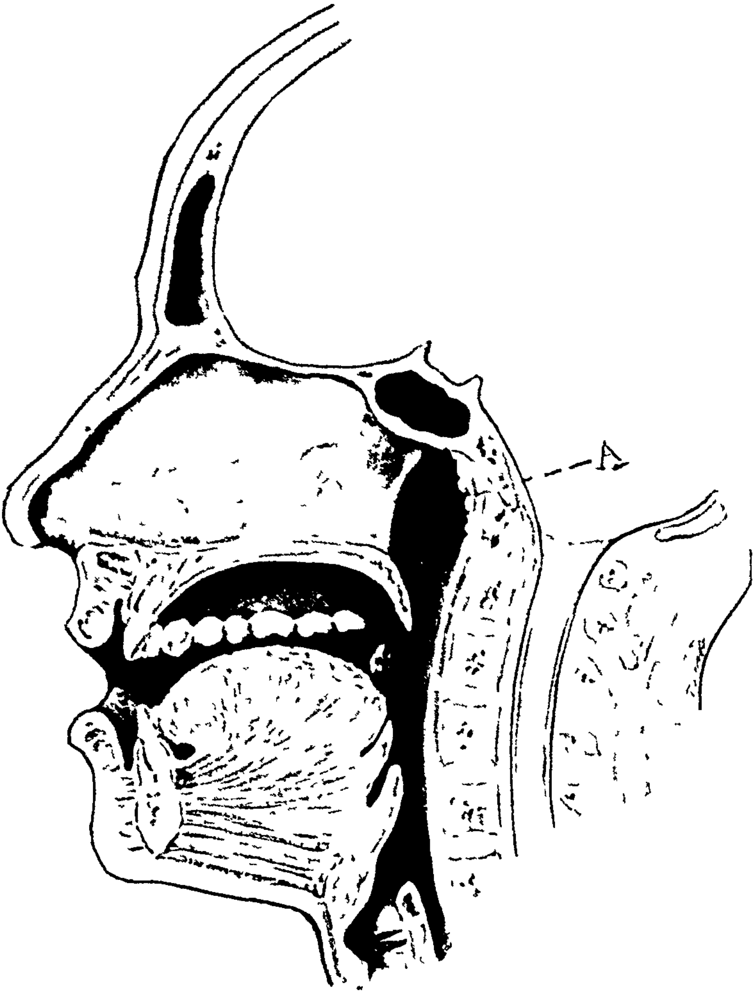

Fig 1 The nasopharynx A lymphoid tissue structure

branes, especially along the intestinal tract and the air passages in the lungs The lymphoid organs are closely associated with the lymph vascular system

According to Drinker and Yoffey,[2] lymphoid tissue consists of a mass of free cells, the vast majority of them lymphocytes of various sizes, together with a supporting framework of reticulum cells and of fibrous elastic and sometimes muscular been derived from animal experimentation Although the main problems entail the role of nutrition and the hormones, some factors of lesser importance also warrant consideration

Nutrition According to White,[8] an adequate caloric intake is essential for the growth of lymphoid tissue Other workers (Settles, Jackson), likewise, have observed that lymphoid tissue is reduced in amount during starvation (inanition) or malnutrition, and increased above normal by rich feeding, especially in children

The protein content of the diet is an important factor in relation to lymphoid tissue growth Proof of this is afforded by restricting the intake of proteins or essential protein constituents[9] If an increase in total serum protein takes place, it is due essentially to an increase in the globulin fraction Lymphoid tissue has a high requirement for pyridoxine Involution of this tissue has been observed in animals on a pyridoxine-deficient diet[10]

Hormones The concept of a hormonal-lymphoid relationship is supported by the fact that the administration of certain hormonal substances alters the size of the tissue mass by reducing or increasing it Evidence suggests, moreover, that the secretion of adrenocortical hormones, controlled by the pituitary adrenotropic hormone, is the normal mechanism regulating lymphoid tissue mass In brief, the pituitary adrenal apparatus influences the size and development of lymphoid tissue[8]

Histologic changes in lymphoid tissue render it possible to determine the effect of adrenocortical hormones Although the effect seems to be prompt, various stimuli are able to augment the secretion of adrenotropin As the rate of secretion of this substance is increased, the production of adrenocortical steroids is increased The result is that the steroid hormones influence in particular the processes which yield to its stimulation The accelerated release cannot occur, however, in the absence of adrenotropic hormone[8]

Criscenti[11] investigated the relationship between the endocrine glands and Waldeyer's lymphatic ring By controlled studies on dogs he was able to show a reduction in size of the a filtering and defense mechanism[2] The lymph structures of the nasopharynx probably have the same functions as those of the general lymphatic system[3] Hochfilzer[4] held that the function of the lymphatic system of the oropharynx depends on the whole lymphatic plexus Like others, Sharp[5] assumed that the function of the postnasal lymphoid tissue was protective in nature He stated "Developing, as it does, in common with lymphoid tissue elsewhere in the body, it is ideally situated to act as a protective filter to the respiratory passages during early childhood, when infection is frequent and development immunity low"

Lymphoid tissue is said to be concerned in antibody formation Although knowledge of the role of the cells of the reticuloendothelial system in this regard is indeed meager, it is reasonable to accept the conclusion of Topley and Wilson,[6] "that the tissue cells themselves are capable of producing antibodies in the fully formed state" On the one hand, according to Semenov,[7] tonsils and adenoids produce lymphocytes, and on the other, they destroy them

For the purpose of clarification, Yoffey and Courtice[3] drew an analogy between the function of lymphoid tissue and that of certain other organs They contended that the production of lymphocytes is as much a normal function of lymphoid tissue as is the formation of digestive juices a function of the intestinal mucosa, or the formation of bile, a function of the liver

Yoffey and Courtice[2a] acknowledged that "difficult, as it may be to understand the role of lymphoid tissue in disease, the problem becomes even more perplexing when we consider the function of lymphoid tissue in health" In the latter state, the following functions have been listed by these investigators *1* lymphocyte production, *2* metabolism and transport of protein and fat, *3* vitamin storage, *4* elaboration of internal secretion, *5* destruction of red cells, *6* the provision of nucleoprotein and other substances as adjuvants to cell growth"[3]

GROWTH OF LYMPHOID TISSUE

Knowledge concerning the growth of lymphoid tissue has with fixed changes Because of this, treatment is not uniformly successful

HYPERPLASIA OF NASOPHARYNGEAL LYMPHOID TISSUE

In a study conducted 15 years ago, Szanto and I[14] pointed out that of the various concepts concerning the development and involution of nasopharyngeal lymphoid tissue, the one more commonly accepted is the so-called "cranio-caudel development" of Waldeyer's ring Since a complete description of this aspect must necessarily embrace all of the structures of Waldeyer's ring, it is not within the scope of this present writing Suffice, that development of the nasopharyngeal tonsil begins after birth and attains its peak between the second and third years of life At puberty, involution of this structure, generally but not always, approaches completion Under abnormal circumstances, however, especially in the presence of allergy or chronic infection, hypertrophy of lymphoid mass usually persists This pathologic change is the replacement for atrophy which, under normal circumstances, would develop and progress throughout life

Infancy and Childhood Hypertrophy* (or hyperplasia) of nasopharyngeal lymphoid tissue in infancy or childhood is usually referred to as adenoiditis (see Fig 3) This tissue normally is of greater amount in the child than in the adult, decreasing steadily in size as age advances Because of its situation and the type of mucous membrane covering it, the adenoid plays a prominent role in respiratory physiology If this lymphoid mass becomes enlarged, crowding the post-nasal vault, it loses its defensive powers and provides a culture-bed for infection which readily spreads to contiguous structures Respiratory and otologic complications are inevitable consequences

Older Persons It is generally assumed that at puberty involution of lymphoid tissues nearly always approaches comtonsillar structures with Cortisone and ACTH He realized, however, that the effect would be reversed when the hormones were discontinued, but he held out hope that through some future device the effect would be rendered permanent

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*According to Warren (Pathology Edited by W D Anderson 3rd Ed The C V Mosby Company St Louis 1957) Hypertrophy is increase in size of an organ or tissue without increase in number of its component units 'Hyperplasia is increase in size with increase in number of component units 'Hypertrophy may be recognized by an increase in unit size Hyperplasia may be recognized by an increase in unit number and if that increase is still taking place when the tissue is studied mitoses will give visible evidence of the proliferation.

Observations like these, according to White,[7] serve to explain why the various physiological changes affected by pituitary-adrenocortical secretion may be seen, to a qualitatively similar extent, in response to a wide variety of agents and in diverse circumstances White contended that this endocrine mechanism is undoubtedly the physiologic basis for the so-called accidental involution of lymphoid tissue seen in the "alarm reaction" of Selye,[12] inasmuch as stress, whether physical or chemical, is one of the potent activators of pituitary-adrenocortical secretion

Miscellaneous Factors Lymphoid tissue mass can be influenced also by factors not related to the pituitary-adrenocortical mechanism For example, alterations in mass size have been produced in the hypophysectomized or adrenalectomized animal by exposure to radiation, mustard gas and the like, or by the injection of certain toxic substances [2a]

Although infection in lymphoid tissue usually affects the size of its mass, this change, contrary to general belief, is not invariable Nasopharyngeal tissue undergoes cellular arrangement in response to many systemic diseases The role of adrenal insufficiency in producing delayed involution of lymphoid tissue has already been mentioned Allergy and some of the major blood disorders have been described prominantly in this connection [13] As concerns allergy, clinical experience points to it as one of the common causes of lymphoid tissue enlargement After seeing so much recurrence even following exact surgical intervention, Meltzer[14] concluded that allergy undoubtedly plays a cardinal role In his opinion, this contention is strongly supported by the number of patients in whom improvement is seen following allergic management Although my own observations from the standpoint of etiology are in strict accord with those of Meltzer, I have not shared his encouraging attitude concerning the allergic aspect In my experience, allergy as a factor is not usually considered until the nasopharyngeal process has developed

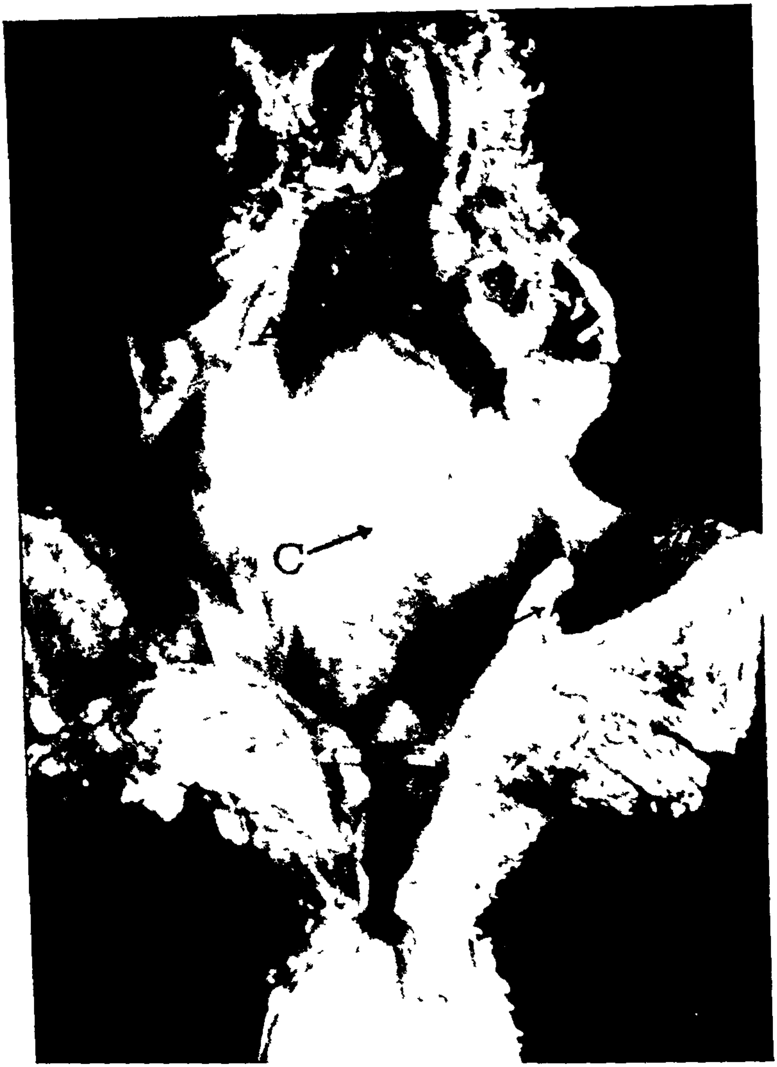


Fig 4 Specimen from a woman aged 75 years A nasopharyngeal tonsil showing pronounced hyperplasia B septum nasi C posterior wall of pharynx D epiglottis

new, however, is attested by the reports of earlier workers Chiari,[16] as early as in 1903, recorded that hypertrophy of the nasopharyngeal tonsil may develop in persons over 60 years of age Despite the possible clinical significance of this tissue in older persons, it has not attracted the interest it merits

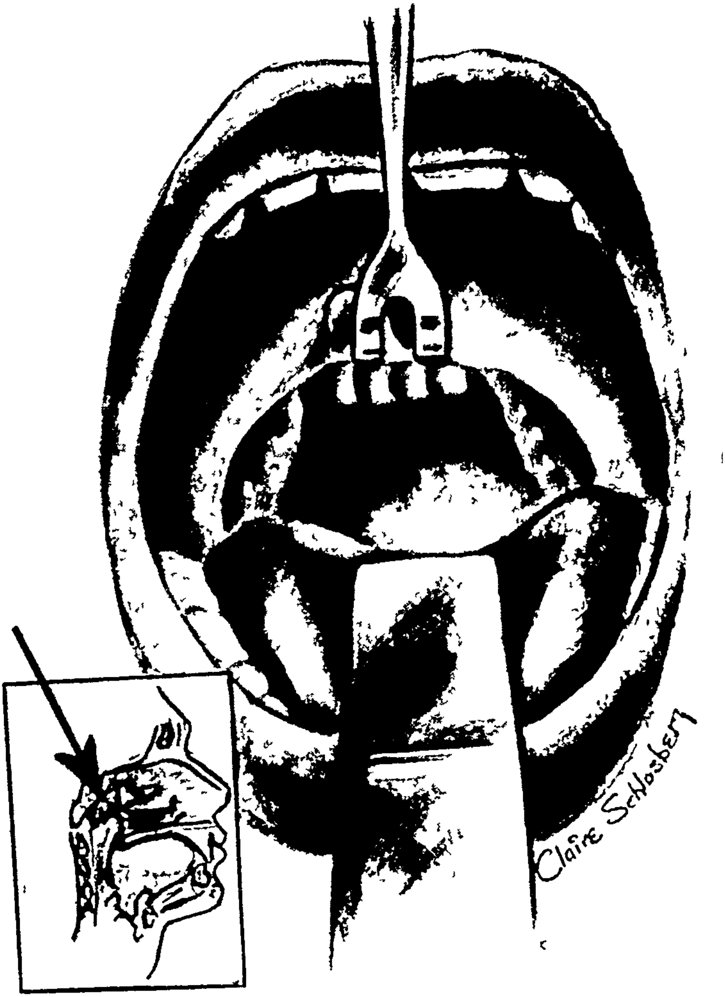
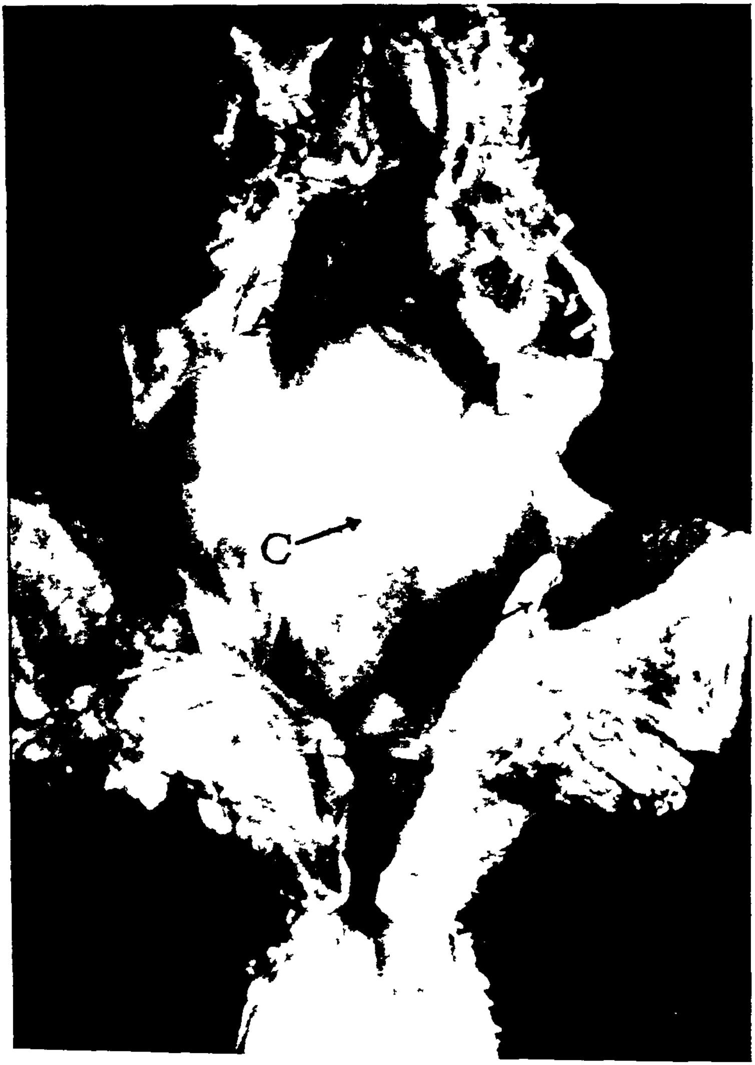


Fig 3 Adenoiditis in a child Hypertrophy or hyperplasia of nasopharyngeal lymphoid tissue indicated by arrow in insert

pletion This is an erroneous assumption, because in a study of 140 autopsy specimens, Szanto and I[15] found the incidence of nasopharyngeal lymphoid hyperplasia in older persons to be relatively high, in fact, it was not an especially uncommon finding in specimens from subjects after the sixth or seventh decades of life (see Fig 4) That this observation was not



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This may be due to the fact that frequently the process is completely devoid of clinical symptoms, on the other hand, the hyperplastic tissue may be completely overlooked merely because the age factor militates against its presence It was of considerable interest, therefore, to detect lymphoid tissue blocking the eustachian tube orifices in a high percentage of persons of advanced age studied for causes of hearing loss[1] The loss, in most instances, erroneously had been ascribed to the age factor

CLINICAL IMPLICATIONS

According to Robb-Smith,[18] the disorders of the lymphoid tissue of any region of the body must be divided into two categories *1* those initiated by local conditions limited to that region, *2* those in which there is a generalized abnormality of the lymphoid tissue throughout the body, and, therefore, the lymphoid tissue of the special region undergoes a similar process "It may be from a clinical point of view," stated Robb-Smith, "that the regional involvement is the presenting symptom of a generalized lymphoid disorder but that in no way justifies its isolation from the point of view of nosography"

"In either category," Robb-Smith continued, "the change in the lymphoid tissue may be reactive, that is to say, the result of stimuli of which we have some knowledge, or idiopathic, in which we have at present no real knowledge of etiology, though we may know much about the morphogenesis of the condition"

Hypertrophied nasopharyngeal lymphoid tissue, regardless of the cause of the pathologic change, often creates or accounts for various clinical problems, more especially in infants and children In otolaryngology, the main concern is for pathologic processes resulting in the respiratory and auditory organs, difficulties arising largely from the anatomic relationships of the involved structures Of practical consideration is the question how to deal with these processes when they are encountered According to Robb-Smith,[18] "if a logical plan is to be pursued in a lymphoid hyperplasia of the nasopharynx, it is necessary to determine whether it is a local reactive condition in which the treatment is that appropriate to the causative factors, or whether it is part of a generalized lymphoid hyperplasia, even where the nasopharyngeal symptom is the primary manifestation, the treatment is then that of the general disease, and a local eradication is no justification for assuming a cure"

How many of us go beyond elimination of the local process? How many of us consider the likelihood that the nasopharyngeal lymphoid mass is merely the local manifestation of a generalized process? Isn't it reasonable to assume that lack of therapeutic success in some instances can be accounted for by this omission?

THERAPEUTIC CONSIDERATIONS

Currently available therapeutic methods, surgery and radiation, often fail in producing successful results because their influence is restricted to the local pathologic process Postoperative recurrence of lymphoid tissue is frequently, but not always, attributable to surgical inadequancy Failure to arrest the abnormal regenerative activity of the lymphoid organs may be responsible for tissue regrowth The problem resolves itself in recognizing the absolute necessity of treating the patient and not merely the local disease process

Logically, the therapeutic approach should emphasize first *prophylaxis* If it were feasible to control allergy and reinfection of the respiratory tract in infancy and childhood, the incidence of abnormal hyperplasia of nasopharyngeal lymphoid tissue could be rendered negligible If control of allergy and respiratory tract infection could be made more effective after surgical removal, tissue recurrence might be held to a harmless minimum

The second therapeutic approach should include an assessment of the patient's general physical state with special reference to possible endocrine dysfunction Since it is now known that, under certain circumstances, hormonal drugs will reduce or shrink lymphoid tissue mass, the essential concern is for some means to render this effect permanent

GENERAL COMMENT AND CONCLUSIONS

Because of its anatomic situation in the upper respiratory tract, the nasopharynx is the main portal of entry for infections and noxious agents The lymphoid tissue contents of the nasopharynx is part of the general lymphoid system which, it is claimed, plays a major role in the process of immunity

Lymphoid tissue growth can be stimulated by the administration of certain hormones, by a high calorie-rich diet, and probably by other factors In animals the growth of lymphoid tissue has been reversed by inanition or by malnutrition, and it may be retarded by exposure to radiation, mustard gas, or by the injection of certain toxic substances Pathologic changes in lymphoid tissue have resulted from infection, allergy, or their combination, with allergy often playing the cardinal role[3 14]

Though the age factor militates against its presence, lymphoid tissue is found frequently in the nasopharynx of persons of advanced age, even in the sixth and seventh decades of life[15]

Disorders of the lymphoid tissue of the nasopharynx may be localized in character, or merely the presenting symptom of a generalized lymphoid disease In the majority of patients, adequate surgical intervention alone, or surgical intervention followed by radiation has proved effective in strictly localized processes If these therapeutic measures fail to produce favorable results, the cause often can be traced to inadequate operative procedure, or the neglect of treatment of the underlying systemic disorder, or to both

SUMMARY

Present knowledge holds to the belief that the functions of the lymph structures of the nasopharynx are similar to those of the general lymphatic system

Of the several concepts advanced concerning the growth and involution of lymphoid tissue, the one of a hormonal-lymphoid relationship merits special consideration

Atrophy of nasopharyngeal lymphoid tissue is not an in-

variable development of advancing age, the incidence of enlargement of this tissue having been found to be relatively high in older persons

Hypertrophied nasopharyngeal lymphoid tissue creates and causes various clinical problems, the main interest in our specialty centering on complications which develop in the respiratory and auditory organs

Failures in the management of nasopharyngeal lymphoid tissue often can be accounted for, *1* by inadequate extirpation, *2* by lack of regard for a possible generalized lymphatic disorder, and *3* by absence of an effective method with which abnormal regenerative activity of the lymphoid organs can be controlled or completely retarded

Theoretically, the ideal would be a method of prevention, adequate control of allergy and reinfections of the upper respiratory tract in infancy and childhood, or following surgical intervention

Hope rests in advances in hormonal preparations through whose effects the activity of the entire lymphatic system could be adjusted or regulated permanently as the indications warranted

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RAPID EXTERMINATION OF NASAL MYIASIS*†

BERT A DEBORD, M D ,

Temple, Tex

Myiasis is the infestation of the body by the larvae of flies The screwworm is the larval stage of the *Cochliomyia Americana,* a fly which has a deep greenish-blue metallic color, yellow face, and three dark stripes on the dorsal surface of the thorax According to Brown,[1] the mature female fly is attracted to some wound or odorous cavity, and only a few seconds are required to oviposit The eggs hatch within a few hours, and the tiny larvae or screwworms immediately begin to burrow and feed on living tissue A screwworm is creamy white and is approximately 1 5 cm in length with 10 to 12 rings or spines encircling its body, giving it the appearance of a screw Two tiny hook-like projections are mounted on the head, and the breathing apparatus is located in the rear The maggot, in contrast to the screwworm, is the larval stage of the ordinary blow fly, and it lives on any dead tissue and does not destroy living tissue

Screwworm infestation in animals is rather common in the South, and is a serious menace to livestock Fortunately, infestation in the human is rare, however, when it does occur, immediate therapy is mandatory because fatal cases of human myiasis have been reported Heretofore, various drugs have been used to exterminate the larvae Chloroform is the agent used most frequently, but, due to the severe irritation and pain from its topical application, an even more effective and less irritating preparation known commercially as Lindane (Hexachlorocyclohexane) is recommended

Case 1—A man, aged 62 was seen in the Clinic on July 15 1950 because of obstruction to the left nasal passage An examination revealed marked deviation of the nasal septum to the left so as to completely occlude the airway The left maxillary sinus was dark to transillumina

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*Read at the Meeting of the Southern Section of the American Laryngological Rhinological and Otological Society Atlanta Ga Jan 23 1959

†From the Department of Otolaryngology of the Scott and White Clinic

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605 Lincoln Road

GILL MEMORIAL EYE, EAR AND THROAT HOSPITAL

The Gill Memorial Eye, Ear and Throat Hospital has just completed its Thirty-second Annual Spring Congress in Ophthalmology, Otolaryngology and allied specialties The attendance was one of the largest in the history of the school with an attendance of 350 physicians and their wives There were forty-two states, England, Canada and several foreign countries represented There were twenty-one guest speakers, sixty lectures and closed circuit televised surgery during the five and one-half days of the Spring Congress In 1960, the Thirty-third Annual Spring Congress will be held from April 4 through April 9

PROGRESS IN PAROTID SURGERY.*

ROBERT E BOSWELL M D ,

Dayton O

To the surgeon the criterion of success is the degree to which he achieves maximum removal or disarmament of a pathological process with minimum disturbance of normal function In dealing with tumors of the parotid gland, which account for the bulk of parotid surgery, anything less than complete removal of the neoplasm results in repeated recurrences, each becoming progressively harder to deal with and correspondingly distressing to the patient At the same time, a powerful deterrent to competent surgery has been the danger of irremediable damage to the facial nerve

HISTORICAL BACKGROUND

The first known attempt to excise the parotid because of a tumor was made by Warren of Boston, in 1804[28] All early efforts to remove tumors and to protect the facial nerve simultaneously were hampered by insufficient knowledge of the distribution of the nerve, by unrealistic concepts of the gland itself, and by failure to appreciate either the physical structure or the malignant potential of the neoplasms commonly found there This ignorance led to the practice of a rather gingerly enucleation of such tumors as were brought to the surgeon's attention This procedure, being only rarely adequate, resulted in such a high rate of recurrence that parotid surgery in general fell into disrepute and came to be avoided as long as possible by both patient and surgeon

As recently as 1933, McFarland,[40] discouraged by the frequency of recurrences following the enucleation of parotid tumors, voiced the opinion that the patient was as well off without surgery Nearly a decade later he still found the

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tion. Submucous resection was recommended, but the patient procrastinated and did not return until October 21, 1950.

Two episodes of postnasal bleeding had occurred during a period of three weeks prior to reexamination. Again, the abnormal nasal septum prevented adequate inspection of the left nasal chamber. A roentgenogram revealed opacity of the left maxillary sinus and loss of definition of the medial wall. On October 26, the left maxillary sinus was explored and a submucous resection was performed. The sinus appeared normal, and erosion through the medial wall of the antrum was not evident. The left inferior turbinate was infiltrated by a rather vascular tumor. Biopsy revealed adenocarcinoma, cylindroma type. The inferior turbinate and tumor tissue was removed and the underlying tissue was electrocoagulated; radium was then applied to the area.

The patient returned on September 29, 1953. Paroxysmal sneezing nasal irritation, serosanguineous discharge and severe pains in the nose had developed. On inspection, a myriad of screwworms literally filled the nose and were gorging themselves on the nasal mucosa. When the diagnosis was made known to the patient, who was a veterinarian, he became extremely apprehensive. He was aware that the screwworms were destroying living tissue, and that they eventually would erode the cribriform plate, possibly causing meningitis or brain abscess. He informed me that Lindane was the drug of choice for exterminating screwworm infestations in animals, and insisted that he be treated with this drug. Since Lindane is highly toxic, cotton tipped applicators were saturated with this preparation, and the surplus was removed to prevent drainage into the pharynx. Application was made to the infested nasal mucosa applying the applicator directly to the larvae where feasible. The screwing motion became retarded, and it was evident that many of the screwworms were dead. By using small nasal forceps, it was possible to remove 62 screwworms. No signs of residual infestation were revealed at subsequent examination.

Case 2.—On September 9, 1957, a transient Mexican laborer complained of severe pain and mild bleeding from the left side of his nose. Three days prior to admission, irritation with slight intermittent bleeding from the nose had been noted. Examination was recorded as follows: "Numerous screwworms are present throughout the left nasal chamber, posteriorly in the floor of the nose. The mucosa appears atrophic and somewhat ulcerated and has a moth eaten appearance. A little bleeding is evident. Rosenmuller's fossa on the left has a swollen, granular appearance, and several screwworms are noted in the orifice of the eustachian tube." After applying Lindane to the larvae, more than 100 screwworms were grasped with forceps and removed. Those in the eustachian orifice were difficult to eradicate; however, all but one of the screwworms were removed by manipulating a small cotton tipped applicator under the guidance of a nasopharyngoscope. The following morning, the patient expectorated the lone worm. His convalescence was uneventful.

SUMMARY

Lindane was found to be a very effective agent for exterminating screwworm larvae from the nasal chambers of our two patients with nasal myiasis.

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the areas of surgical anatomy of the gland and histology of the tumors found there Let us consider a few of these concepts and their effects upon methods of treatment

THEORY OF ENCAPSULATION OF TUMORS

Belief that tumors of the parotid are generally encapusulated was a large factor in the non-selective practice of enucleation Its success was doomed by the unusual nature and structure of the great majority of these neoplasms, that group generally termed "mixed tumors" It is now known that the tumor capsule, if one exists, need not be complete,[38,62] that "pseudopods" of the tumor often extend, undetected, into the surrounding tissues,[58] and that even the slightest, probably unnoticed, nicking of the tumor is sufficient to seed the area with cells which may lie dormant for years before finally developing as recurrences[28] Appreciation of these factors leads to the corollary that infinite care must be taken to avoid spillage of tumor cells, and that one must excise at least a protective margin of normal tissue around the entire periphery of the neoplasm[46,50]

It has also been discovered that the obvious tumor is likely to be only a fractional part of the whole neoplasm, which Bailey so aptly likened to an iceberg with its greater part submerged[4] This realization indicated the need for complete exposure of the gland as an assurance that no remnant of the tumor be left behind

THEORY OF BI-LOBED STRUCTURE OF THE GLAND

A concept of the parotid as a bi-lobed structure, with the facial nerve lying between the parts in a more or less set pattern, molded the surgical approach for many years, and is still the subject of debate

Gregoire, in 1912, was first to describe the gland as bilobed[23 30] A few years later McWhorter is said to have demonstrated, to the satisfaction of his audience in 1917 that the facial nerve lies between the superficial and the deep lobes,[64] but again it remained for Bailey to popularize the idea, as he did by referring to the facial nerve as "meat in a parotid methods of determining prognosis "no more accurate than the flipping of a coin "[41]

Complete parotidectomy, with preservation of the facial nerve, has been practiced for more than half a Century The first account of this procedure came from Carwadine in 1907,[31] but in a few years other isolated and intermittent reports began to trickle in Vilray Blair,[32] Barbat,[6] Sistrunk,[59] and Adson [2] These received very little attention, perhaps because an attitude of pessimism was too firmly embedded, perhaps because the procedures described were not uniformly successful, even when practiced by the men who originated them

In 1934 a different approach was devised independently by Redon, in France, and by Janes, in Toronto,[32] but it aroused no immediate interest The following year Bailey performed a similar operation, though apparently he did not report his success or describe his procedure until years later [5] Its cardinal principles were first, immediate identification of the facial nerve trunk where it emerges from the stylomastoid foramen, and second, full exposure of the parotid gland At the same time, he presented what was later termed the first accurate description of the surgical anatomy of the region, though there has since been reason to differ with some of his interpretations

With the publication of Bailey's work, the pendulum began to swing away from the old policy of avoiding, delaying, and dangerously limiting the surgical attack on parotid tumors After it was demonstrated that parotidectomy with preservation of the facial nerve was an attainable goal, there developed a trend toward making complete excision of the parotid the routine treatment for all of its tumors Somewhere between these two extremes probably lies a more satisfactory answer to the long-standing question of successful treatment

From time to time, various conflicting theories have had their turn at governing the surgical approach to tumors of the parotid gland Some of these conflicts now seem safely settled, while other theories remain highly controversial As in most contentions, the chief disagreements probably stem from a lamentable lack of definitive knowledge, especially in tumors.[29] The value of various diagnostic measures is warmly argued. A great many different classifications of parotid tumors are currently offered. Perhaps, most important of all, and despite the enormous contributions made by Maxwell, Conley, Foote, Frazell, Buxton, Levine, and others, much still remains to be done in the field of histology.

Diagnosis and Evaluation

On at least one point there is complete agreement: the great majority of parotid tumors manifest themselves as a small, painless lump along the jaw line.

Subsequent growth may be so slow, intermittent, and undisturbing that it remains nearly unnoticed by the patient, who is thereby encouraged to delay in seeking treatment. If the rate of growth is suddenly accelerated, if pain develops, if cervical nodes swell, or if any degree of facial paralysis occurs, then the tumor is almost certainly malignant, but even without such distressing symptoms, the potential of malignancy always exists.

Clinical evaluation formerly was based solely on palpation and inspection, considered in the light of the patient's history but it may now be supplemented by sialography, though opinions differ as to its value.

The use of sialography as an aid in the diagnosis of neoplasms of the salivary glands was first reported in 1937, by Kimm, Spies, and Wolf.[25] As with every new device, some enthusiasts hailed it as the answer to all problems in the bothersome differential diagnosis of parotid tumors; to such optimists, sialography proved disappointing.[1] Blatt, Maxwell and associates,[15] and more recently Rubin and Holt,[16] have concluded that the procedure can determine whether a tumor is encapsulated or invasive, but not identify the histologic type. Bever and Blair[13] believe that this is sufficient to differentiate "mixed" tumors from malignant tumors and to determine whether or not malignant degeneration has taken place; however, some authorities consider the term "mixed" to be synonymous with "benign," while others postulate that a "mixed" tumor may be either benign or malignant. Greater uniformity in terminology would help to settle this point.

sandwich"[4] Acceptance of this idea probably engendered greater confidence in surgeons who were aware of the need for more than a mere enucleation but yet were fearful of disturbing the facial nerve Unfortunately, its over-simplification encouraged a less careful dissection than the situation requires, and too often resulted, ultimately, in the very complications which its adherents sought to avoid

Today, if one reads accounts of the studies made by Ariel,[3] Beahrs,[10,11] Byars,[21] Hurford,[30] Peacock,[37] Slaughter,[60] and Winsten,[67] he must conclude that no matter what the normal anatomy, in the gland distorted by pathology the facial nerve courses through the parenchyma, and for purposes of surgical treatment the parotid must be considered as a single unit, regardless of its embryological structure

On the other hand, if one studies the reports presented by Brintnall,[18] by Davis and associates,[23] by Levine,[37] and by Utendorfer,[64] he finds equally convincing evidence of the bilobed nature of the gland

It seems possible that the distinct difference in the consistency of the facial nerve, as opposed to the parotid gland, has so facilitated surgical separation of the two organs that on dissection the gland actually simulates a bi-lobed structure, however, it is a dangerous delusion to depend upon lifting one lobe from the other as a means of exposing and protecting the facial nerve during parotid surgery Only since the investigations reported by Davis and associates in 1956 have we had an adequate concept of the complex anatomy and varied patterns of distribution of this nerve

Practically, the facial nerve is where you find it Its safety depends upon diligent seeking, certain identification, and meticulous dissection Whether the parotid gland consists of one lobe or two would seem to be a question of more academic than practical importance

CURRENT PROBLEMS

There are other major points to be debated and important answers to be sought There is no unanimity as to the extent of surgical intervention that is justifiable in attacking benign neoplasm difficult to identify has been labeled a "mixed" tumor, simply for want of a more accurate name.[8]

Histologic Problem of "Mixed" Tumors

The puzzling nature of these neoplasms has long occupied the attention of pathologists.[27,42,52] Why do some of these so-called benign tumors seem to undergo a malignant transformation?

Beyer and Blair[13] feel that there is accumulating evidence that repeated surgery and/or irradiation is responsible for such transformation, but Paymaster[49] asserts that there is no proof that surgical trauma ever caused a malignant change and, furthermore, no evidence that a true mixed tumor ever became malignant. Beahrs[12] found that many tumors which were thought to represent malignant change in a mixed tumor were really cylindromas, and pointed out the difficulty of distinguishing between the two; yet he concluded that some mixed tumors do undergo malignant change. Orloff[47] expressed the conviction that the true mixed tumor is uniformly benign, implying that any later manifestations of malignancy could be attributed to a mistaken pathological diagnosis in the beginning. Buxton and associates,[20] during their investigations, found no factor in any benign tumor which seemed conducive to malignant change. In investigating 99 tumors, Foote found no truly benign tumor which metastasized. Levine concluded that "benign tumors . . . do not tend to become malignant,"[37] he inferred that such tumors as appear to do so are really malignant from the beginning, but that their degree of malignancy "is subject to abrupt change." Vellios and Davidson[65] found the question of malignant change in mixed tumors "debatable."

Such a variety of opinion points to the need for further inquiry into the histogenesis of "mixed" tumors in an effort to refine their differentiation. There may be some hitherto unrecognized element in a quiescent mixed tumor which marks it as capable of malignant behavior. Under the present system of identification, it is obviously a grave error to underestimate the potential of any "mixed" tumor. On the other hand, perhaps unnecessarily extensive surgery is now

After considering the various reports, one may conclude that the greatest possible service rendered by sialography would be a pre-operative warning of the extent of surgery required This should prevent unnecessarily extensive surgery for both non-neoplastic swellings and for limited, benign growths,[7,55,57] conversely, it should provide a pre-operative admonition of the need for an extensive surgical procedure in the treatment of those tumors which are demonstrably infiltrating[14,51]

The role of biopsy is debatable Vellios has asserted that biopsy is always a pre-requisite to effective therapy,[65] but some workers feel that biopsy of no kind is to be tolerated unless accompanied by adequate surgery,[12,30] others maintain that a carefully marked and suitably followed aspiration biopsy is both permissible and helpful[3,47] Since even the so-called benign tumors of the parotid are said to be the most easily transplanted tissues grown in the human body,[70] and the only ones found, so far, to lend themselves to heterogeneous transplantation, experimentally,[58] one can appreciate the urgent need to prevent spillage and seeding, therefore, if biopsy does precede definitive surgery, there must be considerable care that the biopsy site is adequately extirpated at time of treatment This applies also to needle biopsy with the added caution that the site must be effectively marked

Classification

Varied classifications of parotid tumors have been proposed[3,8,9,26,36,38,46,50] For our purpose, perhaps the one suggested by Vellios[65] will be most useful It is reduced to three groupings

1 Benign

2 Malignant, with a long clinical course, and

3 Malignant, with a short clinical course

While there may be general agreement with the broad form of this classification, opinions differ strongly as to the place of certain growths, particularly the "mixed" tumors, within its framework Terminology is confused Varied terms have been used interchangeably, and sometimes it seems that any neoplasm difficult to identify has been labeled a "mixed" tumor, simply for want of a more accurate name[8]

Histologic Problem of "Mixed" Tumors

The puzzling nature of these neoplasms has long occupied the attention of pathologists[27,42,52] Why do some of these so-called benign tumors seem to undergo a malignant transformation?

Beyer and Blair[13] feel that there is accumulating evidence that repeated surgery and/or irradiation is responsible for such transformation, but Paymaster[49] asserts that there is no proof that surgical trauma ever caused a malignant change and, furthermore, no evidence that a true mixed tumor ever became malignant Beahrs[12] found that many tumors which were thought to represent malignant change in a mixed tumor were really cylindromas, and pointed out the difficulty of distinguishing between the two, yet he concluded that some mixed tumors do undergo malignant change Orloff[47] expressed the conviction that the true mixed tumor is uniformly benign, implying that any later manifestations of malignancy could be attributed to a mistaken pathological diagnosis in the beginning Buxton and associates,[20] during their investigations, found no factor in any benign tumor which seemed conducive to malignant change In investigating 99 tumors, Foote found no truly benign tumor which metastasized Levine concluded that "benign tumors do not tend to become malignant,"[37] he inferred that such tumors as appear to do so are really malignant from the beginning, but that their degree of malignancy "is subject to abrupt change" Vellios and Davidson[65] found the question of malignant change in mixed tumors "debatable"

Such a variety of opinion points to the need for further inquiry into the histogenesis of "mixed" tumors in an effort to refine their differentiation There may be some hitherto unrecognized element in a quiescent mixed tumor which marks it as capable of malignant behavior Under the present system of identification, it is obviously a grave error to underestimate the potential of any "mixed" tumor On the other hand, perhaps unnecessarily extensive surgery is now

After considering the various reports, one may conclude that the greatest possible service rendered by sialography would be a pre-operative warning of the extent of surgery required. This should prevent unnecessarily extensive surgery for both non-neoplastic swellings and for limited, benign growths,[7, 55, 57] conversely, it should provide a pre-operative admonition of the need for an extensive surgical procedure in the treatment of those tumors which are demonstrably infiltrating.[14,51]

The role of biopsy is debatable. Vellios has asserted that biopsy is always a pre-requisite to effective therapy,[65] but some workers feel that biopsy of no kind is to be tolerated unless accompanied by adequate surgery,[12, 50] others maintain that a carefully marked and suitably followed aspiration biopsy is both permissible and helpful.[3,47] Since even the so-called benign tumors of the parotid are said to be the most easily transplanted tissues grown in the human body,[50] and the only ones found, so far, to lend themselves to heterogeneous transplantation, experimentally,[58] one can appreciate the urgent need to prevent spillage and seeding, therefore, if biopsy does precede definitive surgery, there must be considerable care that the biopsy site is adequately extirpated at time of treatment. This applies also to needle biopsy with the added caution that the site must be effectively marked.

Classification

Varied classifications of parotid tumors have been proposed.[3, 8, 9, 26, 36, 38, 46, 50] For our purpose, perhaps the one suggested by Vellios[65] will be most useful. It is reduced to three groupings:

1 Benign

2 Malignant, with a long clinical course, and

3 Malignant, with a short clinical course.

While there may be general agreement with the broad form of this classification, opinions differ strongly as to the place of certain growths, particularly the "mixed" tumors, within its framework. Terminology is confused. Varied terms have been used interchangeably, and sometimes it seems that any neoplasm difficult to identify has been labeled a "mixed" tumor, simply for want of a more accurate name[5]

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Such a variety of opinion points to the need for further inquiry into the histogenesis of "mixed" tumors in an effort to refine their differentiation There may be some hitherto unrecognized element in a quiescent mixed tumor which marks it as capable of malignant behavior Under the present system of identification, it is obviously a grave error to underestimate the potential of any "mixed" tumor. On the other hand, perhaps unnecessarily extensive surgery is now being practiced because of the general inability to distinguish between the completely benign and the potentially malignant tumors of this type

Total Parotidectomy vs Local Excision

Routine total parotidectomy for all primary tumors has been recommended by Trueblood,[63] Kidd,[34] Redon,[53] Brintnall,[16] Patey,[48] and by Janes [32] The line of reasoning is thus first, the record of repeated recurrences and the seeming malignant transformation of supposedly benign tumors makes total extirpation of the gland a justifiable prophylactic measure, second, there are no contraindications, since careful dissection insures as much safety for the facial nerve in this as in a lesser procedure, third, if inadequate primary surgery makes later surgery necessary, the second operation is both more difficult to perform and more likely to result in complications

At the other extreme, as recently as 1954 Hunter[29] voiced a preference for enucleation followed by irradiation, rather than risk the hazards of parotidectomy

The conservative view, presented by Devine,[25] Maxwell,[46] Judd,[33] Tabah,[61] Marshall,[43] and Peacock,[50] is that if primary treatment is reasonably early, then a wide local excision generally will prove adequate for all benign growths and for some malignancies While an occasional report still recommends irradiation as a supplement to conservative surgery,[16] many authorities decry that practice [3,12,28]

Perzik expressed the opinion of many contemporaries when he asserted that a subtotal parotidectomy is the procedure of choice [51] Lyle said that a total parotidectomy is indicated only if the lesion is malignant, or if a benign tumor is in the deep lobe [38] Beahrs considered that the minimal procedure is a superficial parotidectomy, while a total conservative parotidectomy is indicated if the tumor lies beneath the nerve [7,10]

The difficulty lies in determining beyond doubt, at time of surgery, that the neoplasm is truly benign, that it is incapable of metastasis, and that no microscopic seed of the original growth remains behind

It is likely that an improved knowledge of the histology of parotid tumors will make possible a finer distinction among "mixed" tumors, so that in the future fewer total parotidectomies will seem necessary for safety's sake; furthermore, education of the public to the need for seeking early treatment may also help to reduce the necessity for extensive surgery.

Methods of Surgical Approach

It is generally agreed that the safety of the facial nerve depends upon its exposure and identification without trauma. To accomplish this requires a detailed knowledge of the anatomy of the region, considerable care in operation, and a dependence upon anatomical landmarks.

A variety of such landmarks have been suggested. As early as 1912, Vilray Blair proposed the digastric muscle as a point of reference,[32] but we find no further mention of it in the literature until referred to by Janes in 1943,[31] although it is again cited in contemporary reports.[17, 22, 44] Seeking the main trunk of the nerve at its exit from the stylomastoid foramen has been a favored custom, though Brintnall and Huffman protest that it may be too difficult to locate, and suggest instead the two bony prominences of the anteroinferior margin of the external auditory meatus and the anterior margin of the mastoid process of the temporal bone as safer guides.[15] Brown[10] prefers to approach the tumor directly and to identify both trunk and branches of the facial nerve as they are incidentally uncovered. Some surgeons have routinely begun with a peripheral branch, which they trace back to the trunk,[2, 31, 36, 39] while others have used the posterior facial vein as a landmark for immediate exposure of the nerve trunk.[21, 35] In general, the preferred procedure is first to seek and carefully expose the main trunk of the facial nerve before any other step is taken. Whatever landmarks the surgeon finds dependable will serve his purpose, which is to protect that nerve.

Unfortunately, the VIIth nerve sometimes must be sacrificed when malignancy invades the parotid. Some authorities assert that no attempt should be made to save the nerve when cancer is recognized,[33] while others advocate sacrifice of the nerve only if the malignancy is either bulky or diffusely infiltrating [61]

There has been some variation in the type of incision preferred The "Y", the inverted "W", and the "J" incisions are variously recommended [9 44,54,66] This would seem to be a matter of personal preference, so long as adequate exposure is achieved with safety

A RECOMMENDED SURGICAL PROCEDURE

The surgical procedure which, in my experience, seems most useful, is herewith briefly described

At present I prefer the "Y" incision (see Fig 1), since it permits upward retraction of the ear, facilitates access to both the anterior and the retromandibular portions of the gland, promotes adequate exposure of the VIIth nerve, the pterygomandibular space, the mastoid tip, and the sternomastoid muscle, and also aids the completion of a radical neck dissection, if that operation should be found necessary The anterior component of the incision facilitates the dissection and isolation of the terminal branches of the VIIth nerve, while the posterior portion permits the identification of the parotid gland and reveals its relationship to the sternomastoid muscle The two components of the incision meet under the lobule at a relatively obtuse angle and then are carried downward along the sternomastoid muscle to the tip of the greater horn of the hyoid bone At this point the parotid separates easily, unless involved in malignancy, and can be retracted anteriorly

It is now imperative that the main trunk of the facial nerve be identified (see Fig 2) I find that the most helpful landmark is the upper border of the posterior belly of the digastric muscle, at the point of its attachment to the mastoid process The anterior border of the mastoid process itself, above the digastric muscle, is also a dependable guide By careful dissection to a depth of 1½ to 2 cm below the skin at this point, the main trunk of the nerve can be located It will be helpful to remember that the VIIth nerve is the only nerve in this area which runs in a transverse direction and that its width

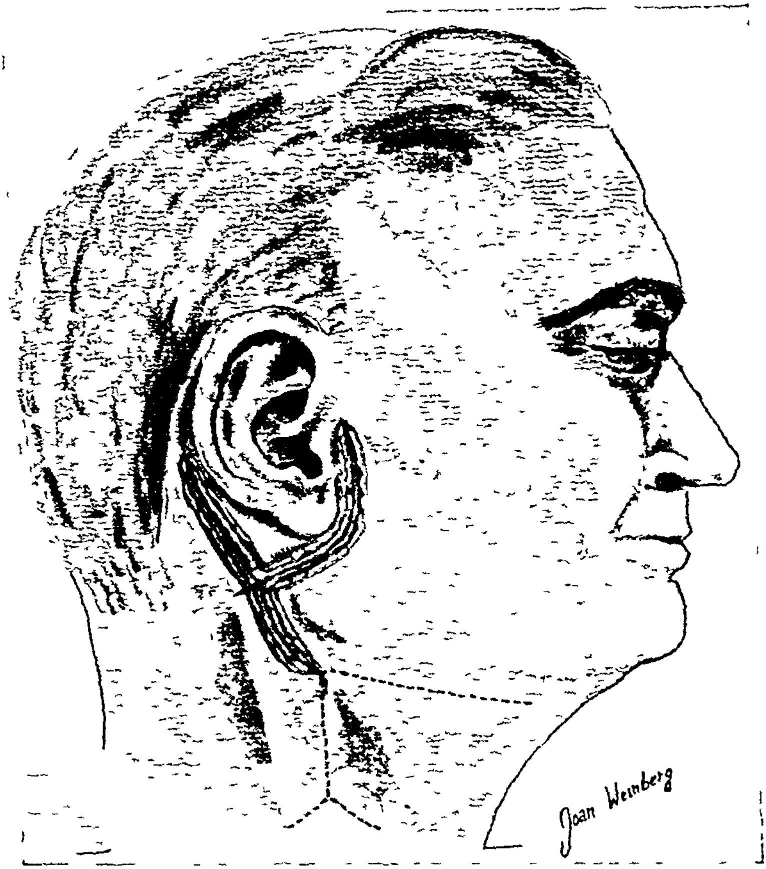

Fig 1 The Y incision

at the point of origin from the stylomastoid foramen is from 2 to 3 mm

As soon as the facial nerve has been exposed, identified, and assured protection, then one must decide upon the extent of resection to be done

I am convinced that the routine removal of all parotid tissue superficial to the VIIth nerve is the wisest procedure, except when dealing with either very small and superficial neoplasms located near the periphery and no more than 1 cm in diameter, or else tumors whose greater ramifications immediately become obvious Such routine procedure offers a protection out of all proportion to whatever additional risk it may carry

Transient nerve paralysis is to be expected if nerve trauma is incurred at all, but with careful technique the injury will be minimal, and my experience leads me to agree with Martin[15] that the paralysis will disappear within three or four months, however, one should take care to warn the patient, before surgery, that such a condition may arise and to assure him that restoration of nerve function is confidently expected

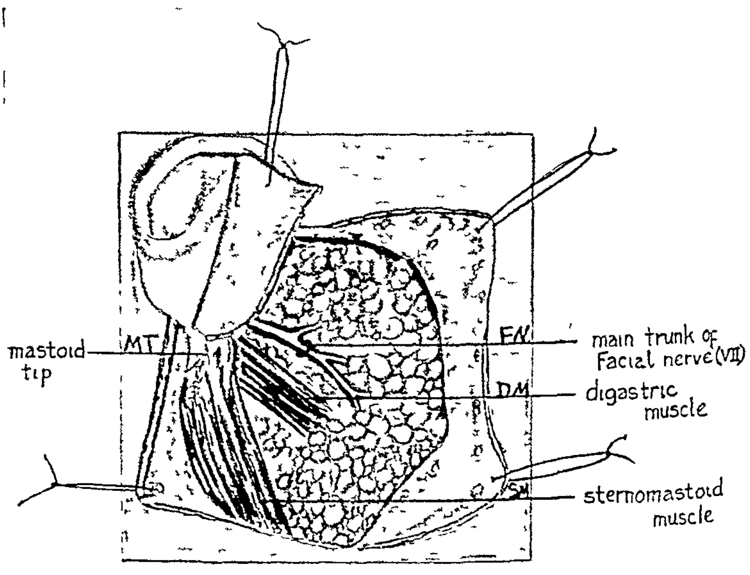

Fig 2 M T—Mastoid Tip F N—Facial Nerve (VII) Main trunk D M—Digastric Muscle S M—Steromastoid Muscle

INDICATIONS OF PROGRESS

Progress in parotid surgery is best illustrated by the striking diminution in both the recurrence rate of supposedly benign tumors and the incidence of postoperative complications

The recurrence rate has dropped from Wood's conservative report of 50 per cent in 1904[34] to the equally conservative 4.8 per cent announced by Frazell in 1954.[28]

Possible postoperative complications are Frey's syndrome, salivary fistula, and facial paralysis. Incidence of the first two has become negligible,[28] while facial paralysis, once the dreaded concomitant of even the most superficial parotidectomy, is now a rare accident in the initial surgery of any benign growth. It is a distinct mark of progress that today the facial nerve never need be seriously and permanently impaired, except by deliberate intent such as during the pursuit of a deep-seated malignancy.

It would seem fair to conclude that noteworthy progress in parotid surgery began with the practice of bold exposure of the gland itself, safeguarded by immediate isolation of the facial nerve, and motivated by a growing appreciation of the structure and potential growth patterns of the neoplasms found in this area.

With continuing improvement in surgical techniques and increasing knowledge of histology, it is reasonable to expect that the recurrence rate of benign parotid tumors should approach the zero percentile.

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CORRECTION

The paper entitled "Regression of Hearing Improvement after Mobilization of Stapes" published in the March, 1959, issue of THE LARYNGOSCOPE, should bear the name of Dr Richard J Bellucci only Dr Dorothy Wolff wishes it to be known that she in no way helped to assess the results of this surgery and, therefore, her name should not appear on this paper

MASTOID PNEUMATIZATION A CASE WITH INTERESTING DEVELOPMENTAL AND PHYLOGENETIC ASPECTS [*]

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Bay Pines, Fla

It is generally accepted that the mastoid antrum is the mother of all mastoid cells It is known, however, that hypotympanic cells invade the mastoid on occasion It is the aim of this paper to present a case apparently demonstrating a hypotympanic-mastoid tip cell tract, and to discuss this tract regarding incidence, anatomy, clinical aspects, and radiological and phylogenetic considerations

INCIDENCE AND ANATOMICAL CONSIDERATIONS

A tympanomastoid tract is not an anomaly or mutation Its anatomical course and relations are too constant, and as will be discussed later, there are phylogenetic aspects which support this view Wittmaack[1] in 1918, described a tract of cells in infant temporal bones which he believed was concerned in pneumatization of the mastoid tip from the middle ear Almour[2] in 1933, confirmed this in adult temporal bones, finding such a tract in 100 per cent of 24 well pneumatized adult specimens He described the course, from the tip to the hypotympanum, as follows "From the tip the course of the cell is upward and inward along the posterior canal wall, and then inward overlying the lateral sinus until it reaches an area located posterior to the jugular bulb It then runs underneath the facial nerve to emerge in the middle ear at the innermost part of the junction between the posterior and inferior tympanic walls "

Bast and Forester[3] in 1939, studied histologically 96 specimens and observed that in only a few specimens mastoid air

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[*] Read at the Meeting of the Southern Section of the American Laryngological Rhinological and Otological Society Atlanta Ga, Jan 23 1959

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cells opened low into the middle ear directly anterior to the facial canal Lindsay[4] in 1940, dissected 100 temporal bones in a study directed primarily to the petrous pyramid, and described pneumatization of the infralabyrinthine area in 25 per cent In 13 per cent there was a tract from the hypotympanum to the mastoid, with the exact portion of the mastoid not given In 3 per cent the hypotympanic tract led to the infralabyrinthine area only In 8 per cent there was a tract from the mastoid to the jugular bulb, or round window niche region, but not communicating with the hypotympanum proper He concludes, in a clinical consideration, that in the majority (with no hypotympanic drainage) there is a greater tendency for suppuration to be walled off, than in those cases where there is an opening to the hypotympanum Singleton[5] in 1944, dissected 100 temporal bones and found nine tympano mastoid tracts He stated that usually the retrofacial and infralabyrinthine cells arise from the antrum and extend downward and inward to their destination below the posterior semicircular canal and adjacent to the jugular bulb, but that occasionally these cells arise from the middle ear cavity, pass medial to the facial canal and reach the same location

Farrior[6] in 1949, stated that the hypotympanic cells posteriorly may extend medial to the facial nerve and are usually responsible for the retrofacial and infralabyrinthine cellular development He further noted that hypotympanic pneumatization is highly developed in the anthropoid apes, and is rudimentary in man Attention is called to the following observations from the above There is variation in the reported incidence of hypotympanic pneumatization of the mastoid, ranging from 100 per cent of well-pneumatized bones to merely an occasional case It is also noted that since Wittmaack's original observations and Almour's confirmation, the mastoid tip itself is not mentioned, though Wittmaack considered this a separate process concerned primarily in pneumatization of the tip In short, there is some agreement for an appreciable incidence of pneumatization from the hypotympanum for the infralabyrinthine and retrofacial areas, but with some reluctance to recognize further extension to the mastoid tip

CLINICAL CONSIDERATIONS

An observation of Lindsay's has already been mentioned above Almour points out certain clinical considerations of hypotympanic pneumatization of the tip It demonstrates that it is possible for infection to spread from the middle ear to the tip without involvement of the antrum It explains those cases with early mastoid tip tenderness in acute purulent otitis media Similarly, it explains the X-ray study depicting intact cells about the antrum and the greater part of the mastoid in the presence of exquisite tip tenderness It also accounts for the operative finding of isolated empyema of the mastoid tip cells with the remainder of the mastoid cells intact He even suggested that with careful study of X-ray plates, close observation clinically and at the operating table, it may be found that isolated tip empyema can be cured without complete exenteration of all mastoid cells He further states, and keep this in mind when the author's case is presented, that it is conceivable that only the mastoid tip may be pneumatized with the remainder of the mastoid process sclerotic or diploic

RADIOLOGICAL CONSIDERATIONS

Schillinger, an otolaryngologist and instructor in otolaryngologic radiology, published interesting studies on pneumatization of the mastoid in 1938 and 1939[-8] He attempted a correlation of Roentgen findings to anatomic and clinical concepts He feels that the classification of mastoids as pneumatic, diploic or sclerotic is neither informative anatomically nor of great assistance otologically He proposes an anatomic classification based on a roentgenologic study in the first six years of life, during which time the adult pattern can be seen to develop The fundamental anatomic structure which is well seen on the X-ray film at age two is the peri-antral triangle This roughly represents the base of the petrous pyramid and contains the antrum, peri-antral cells and labyrinth It is bounded posteriorly by the groove of the sigmoid sinus and above by the tegmen of the antrum and middle ear The study is based on the pattern of development of cells as they extend beyond the boundaries of this basic triangle from ages two to six Cells are described as originating from the antrum and hypotympanum in three distinct tracts termed squamal, antral and tympano-tip It is assumed that the squamal cells originate from the squamosal or lateral segment of the antrum and invade the squamo zygomatic region Schillinger's discussion of a squamal tract is remindful of DeLisa's paper on squamositis (1949) [9]

The antral cells make up the largest tract and presumably originate from the medial or petrosal portion of the antrum The cells of hypotympanic origin, the tympano-tip tract, are considered by Schillinger as a normal development which pneumatizes the tip and anterior face of the mastoid process in a characteristic manner Each tract is best demonstrated when it develops alone or the tracts are only partially developed, so that there is not too much obscuration by overlapping When fully developed the tympano-tip tract extends to the emissary vein region posteriorly and is responsible for the broad, pneumatized tip, when it fails to develop the tip is narrow or pointed and is either diploic or partially invaded by antral cells Illustrative diagrams and roentgenograms are presented in the papers which are quite illuminating Schillinger classifies mastoids into two main groups those with normal development and those with defective development Under defective development are listed the undeveloped mastoid (exhibits no extension beyond the peri-antral triangle) and the partially developed mastoid which presents each of the three tracts, alone or in various combinations

PHYLOGENY

It is a general axiom, not always true, that a phylogenetically older structure will appear earlier in the embryo The ossicles of the middle ear, *e g*, are apparent as early as the fourth week (stapes) [10] The mastoid process, on the other hand, is not formed until after birth, being only a small tubercle behind the upper part of the annulus tympanicus (Politzer) at birth It is not apparent externally in animals below the anthropoid apes, and only attains a true mastoid or breast-like configuration in man It has been proposed that the mastoid process develops in response to the pull of the sternomastoid (Alexander)[10] and, or the splenius capitis[11] muscles engaged in maintaining the head in an erect position

A fascinating phylogenetic development beyond the scope of this paper, but meriting at least summarization, is the transition from the monossicular (columella) system of the premammalian reptiles to the triple ossicular system of mammals The ossicles are derived from the masticatory apparatus, which on the surface might appear an odd source From a functional standpoint, however,[13] it might be conjectured that there occurred a mutually beneficial evolutionary change with the masticatory and auditory apparatus not entirely unrelated The massive jaws of the aquatic premammalian reptiles became secondarily concerned with transmission of sound by bone conduction through an intermediary water and later earth medium In the transition from a water to an air environment there is temptation to conjecture that there was a concomitant change to, *1* a middle ear modified for airborne sound transmission via a triple ossicular system, and *2* simultaneous conversion of the massive jaw mechanism to a lighter one better adapted to function in a less bouyant air environment

The triple ossicular system is characteristic of all mammals from the lowly duck-billed platypus on up the scale The epitympanic recess, also a characteristic mammalian structure, is developed of necessity to house the incudo-malleolar mass[12] In the next higher level, the marsupials, the second purely mammalian characteristic appears, the auditory bulla[10 12] This is an expansion of the tympanic bone, housing a hypotympanic space hanging from the base of the skull in most instances In its simpler form it is monocellular, and perhaps serves as a resonating chamber to magnify simple warning sounds from other members of the same species Both the bulla and epitympanic recess vary from simple one-celled chambers to multicellular systems In the kangaroo, *e g*, the epitympanic recess expands into the squamosa; in moles, the bulla invades the basisphenoid in a multicellular system, in some ungulates, *e g* the cow, the bulla is laterally placed and attaches to the petrosa with a multicellular bullar tip and so as stated by Eggston and Wolff,[10] corresponds to the human mastoid.

Both Tumarkin[12] (from an unidentified source) and Robb and Palmer,[11] quoting Valsalva (17 Century) as the source, make the observation that when the bulla is small there tends to be compensatory enlargement of the epitympanic recess and its associated air spaces. This suggests a competition in an evolutionary sense, between the two systems. The bulla is more prominent in lower mammalian forms with the competition reaching a stalemate in the higher ape forms (gorilla), where both systems are maximally developed. Tumarkin's paper shows the variations diagrammatically for various mammals through the primates, with the mastoid of the higher apes equally pneumatized from both sources. This is a transitional stage to man, *i. e.*, the bulla proper is smaller while the accessory multicellular systems become more prominent as the mastoid itself becomes more prominent.[1] In man there is an apparent ascendancy of the epitympanic recess accessory cell system concomitant with the further development of the mastoid process.

In the highest order of mammals, the primates, the lemurs (a lower form) have a large monocellular bulla with a narrow neck, suggesting a Helmholtz resonator. In the New World monkeys[12, 15] there is a flat mastoid, a tympanic ring without a bony canal and a bulla at its union with the petrosa. There is a well developed accessory air cell system both in the petrosa and the mastoid region. In the Old World monkeys there is a transitional stage to the structure found in man. The bulla proper diminishes in size, and a mastoid bulge is present. A bony external canal is formed, and the cell system is still better developed. In the gorilla the mastoid is a flange-like plate with the digastric groove exposed to view in the lateral aspect.[14] The gorilla particularly has a remarkably wide spread cell system ramifying throughout the mastoid, squamosa and petrosa with the labyrinth and carotid, *e. g.*, suspended in air cells. Hoffman[13] points out that in the anthropoid apes extensive, symmetrical pneumatization is consistently present. In man the accessory air space system rarely attains the extent found in the apes, and is usually greatly reduced especially as regards pneumatization in the petrous portion; also there is often asymmetry between the two sides in man In addition diploic and compact temporal bones are more common in man Whether these are secondary to infantile or prenatal inflammation (Wittmaack) or normal for that individual (Cheatle, Diamant, etc), is not pertinent to the scope of this paper

From paleontology it is learned that the anthropoid apes date back 65 million years [15] Peking man hailed on discovery in 1936 as the "missing link," dates back only 600 000 years His teeth and mastoid configuration are definitely anthropoid however, his larger brain case and his ability to make fire and use tools are humanoid Neanderthal man dates back 200 000 years and his mastoid is described as intermediate between the apes and man

From the above it can be said that a tympano-mastoid tract is not accidental and has precedent in phylogeny It may be atavistic in the sense that it reverts to the time when the epitympanic and hypotympanic cell systems were more evenly matched in their struggle for ascendancy.

CASE REPORT

Present Illness J D C 26-year-old white male IBM machine operator, was admitted Aug 7 1956 with a history of intermittent drainage from the right ear since June 1 1956 and with a right facial paralysis of one week's duration The ear had been treated by unidentified ear drops but with a persistent discharge abating only one week before admission

Past and Family History There is a history of right-sided mastoiditis at age 6 but no mastoid surgery Three of four siblings had ear infections in childhood

Physical Examination A right facial paralysis was present with slight motion persisting in the eyebrows and angle of the mouth and with good muscle tone The left drum was markedly retracted. The right drum showed a friable irregular polyp occupying a posterior *pars tensa* perforation. There was no mastoid tenderness or swelling Hearing in both ears was roughly equal with ordinary conversation readily heard Audiogram showed excellent bone conduction bilaterally flat curves with a 30 db loss for the conversational range on the left and a 25 db loss on the right Fistula test was negative

Laboratory Essentially normal blood count urinalysis and serology Mastoid X-rays were reported as follows Poor pneumatization on the left and incomplete pneumatization on the right More detailed retrospective review by the author reveals the left mastoid largely diploic On the right side there were small cells in the peri antral region with a limited distribution beyond the triangle There were large intact thin walled cells in the tip region (see Fig 1)

Course in the Hospital The polyp was biopsied and reported as a nonspecific granuloma The facial paralysis cleared under antibiotic therapy, but the polyp remained unchanged Two weeks after admission a mastoidectomy was performed The external canal was narrowed A small space containing pus was encountered in drilling toward the antrum The mastoid was infantile in type with a high, anterior and deep antrum, which was found with some difficulty The antrum was a small, flat slit, with a sharp sloping roof and was 3 mm in height It contained a drop of pus The lining was slightly thickened but without trabeculation or visible opening other than the aditus The short process of the incus was slightly granular in appearance The lateral sinus was encountered 12 mm from the posterior canal wall Toward the tip large cells with a normal lining were encountered The aditus was uncapped and the epitympanum seen to be free of disease The posterior canal wall was partially taken down to allow drainage for the diseased portion of the mastoid The tip cells were left largely undisturbed, as was the middle ear proper No graft was applied The cavity was lightly packed open

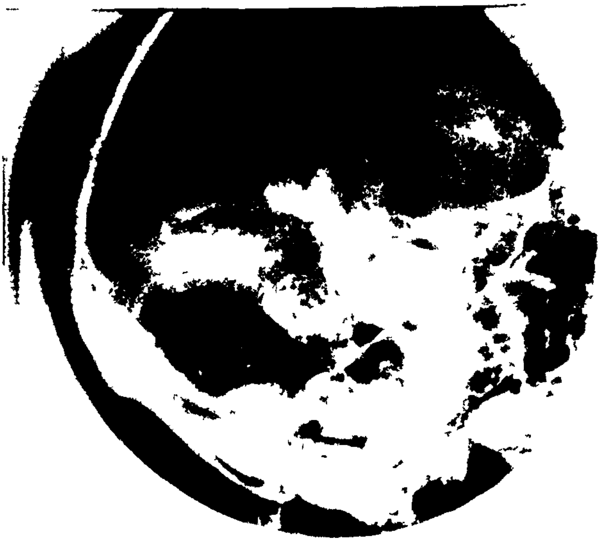

Fig 1

Postoperative Course A sterile mastoid dressing was maintained for six weeks By the end of four weeks the exposed and opened tip cells were seen to have sealed themselves off gradually by primary healing A smooth glistening epithelium had extended from the external canal to almost cover The polyp disappeared and a clean dry perforation remained through which a clean incudostapedial joint could be visualized When last seen 25 months after operation, there was a flat 30 db curve on the right and with a dry, clean perforation A cigarette paper prosthesis gave no improvement in hearing

This was an infantile mastoid with partial, small cell pneumatization of the greater portion of the mastoid draining via a hypoplastic antrum but with a well developed tip cell system It approaches Almour's hypothetical case of a normal tip cell system draining into the hypotympanum and a diploic or sclerotic mastoid otherwise In the above case it must be conceded that hypotympanic origin is based on indirect though considerable evidence Had the author been familiar with Schillinger s work at the time this case presented itself, could he have justifiably predicted the pathological anatomy on the basis of the X-ray? It may be of interest that the patient s mother has one mastoid with only the tip cell system developed but with normal pneumatization on the other side (see Fig 2)

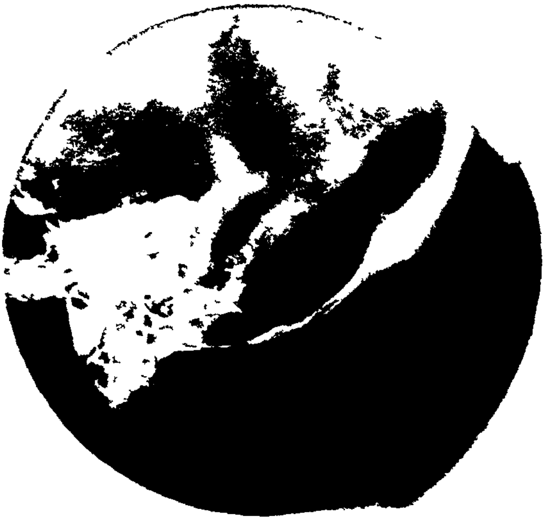

Fig 2

SUMMARY

There is anatomic, clinical, radiological and phylogenetic evidence for a double origin of mastoid cells Retrofacial, infralabyrinthine and mastoid tip cells may be pneumatized from the hypotympanum The incidence of hypotympanic origin of mastoid cells, especially the tip cells, is not well established but is probably greater than is generally appreciated Attention is called to Schillinger's work with X-ray studies which warrants further correlation with anatomical studies

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Veterans Administration Center

FIBROUS DYSPLASIA OF THE TEMPORAL BONE*

HAROLD LESLIE KEARNEY M D ,

New Orleans, La

This report is concerned only with monostotic fibrous dysplasia of bone About this, Schlumberger[3] says "Histologically the primary component of the bone lesion is connective tissue, fairly well vascularized and frequently arranged in interlacing bundles and whorls Within the connective tissue, and most abundant at its periphery, are trabeculae of partly calcified newly formed bone"

In Schlumberger's[3] report of 67 cases of fibrous dysplasia involving single bones, there was only one case of involvement of the temporal bone Brunner[1] reports a case of disease of the malar bone with apparent exostosis of the external auditory meatus, biopsy was done of the malar bone, and the mass in the canal of the ear and fibrous dysplasia was demonstrated in each instance Towson[4] reports a case of fibrous dysplasia of the mastoid in a colored boy 14 years of age I have found only these three biopsy proven cases of fibrous dysplasia of the temporal bone in my search of the literature, however, it may be less rare than the literature indicates, since fibrous dysplasia of the temporal bone may have been reported under other designations Cooke and Powers[2] point out that as many as 33 different titles had been used to describe this entity prior to the introduction of the term "fibrous dysplasia" by Lichtenstein in 1938

Fibrous dysplasia of the mastoid process is an expanding bone lesion, and among its first clinical symptoms may be an occlusion of the external auditory meatus by what appears to be an exostosis This was true in two of the three cases I have found in the literature, and it was the initial symptom in the case reported here by me

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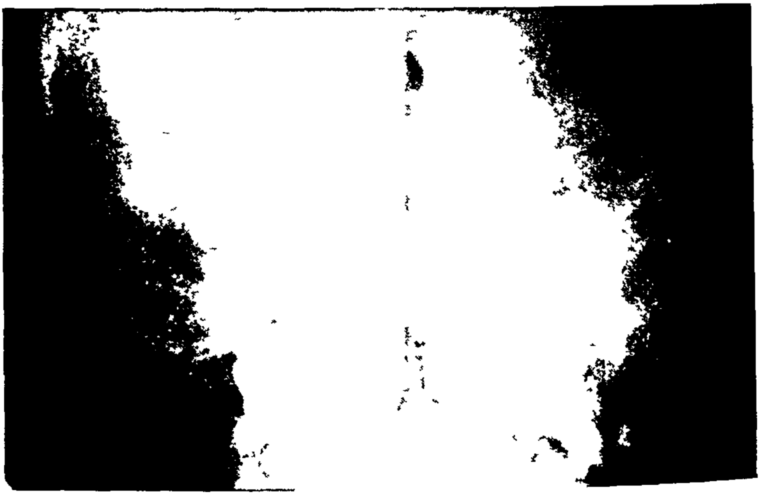

Fig 1 Preoperative X-ray study showing gross enlargement of right mastoid and petrous

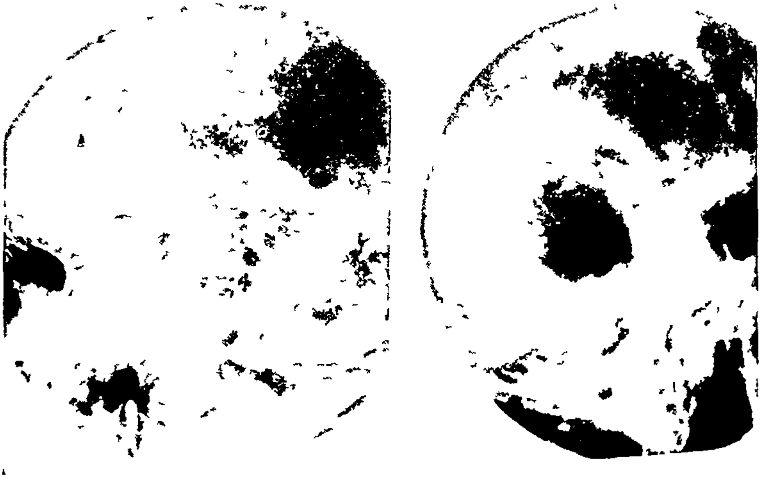

Fig 2 Postoperative lateral view of mastoids showing surgical defect of right mastoid

A S , Jr , was first seen August 9, 1950, at age 21 with the complaint of impaired hearing in his right ear, which was discovered when he was rejected for the Navy in 1948 The right external auditory meatus was obstructed by what appeared to be an exostosis There was no history of trauma to the ear or the head His physical appearance was that of a healthy 21-year old man The Weber test lateralized to the right ear

At X-ray examination the petro mastoid portion of the right temporal bone showed its original contour but was grossly enlarged and contained

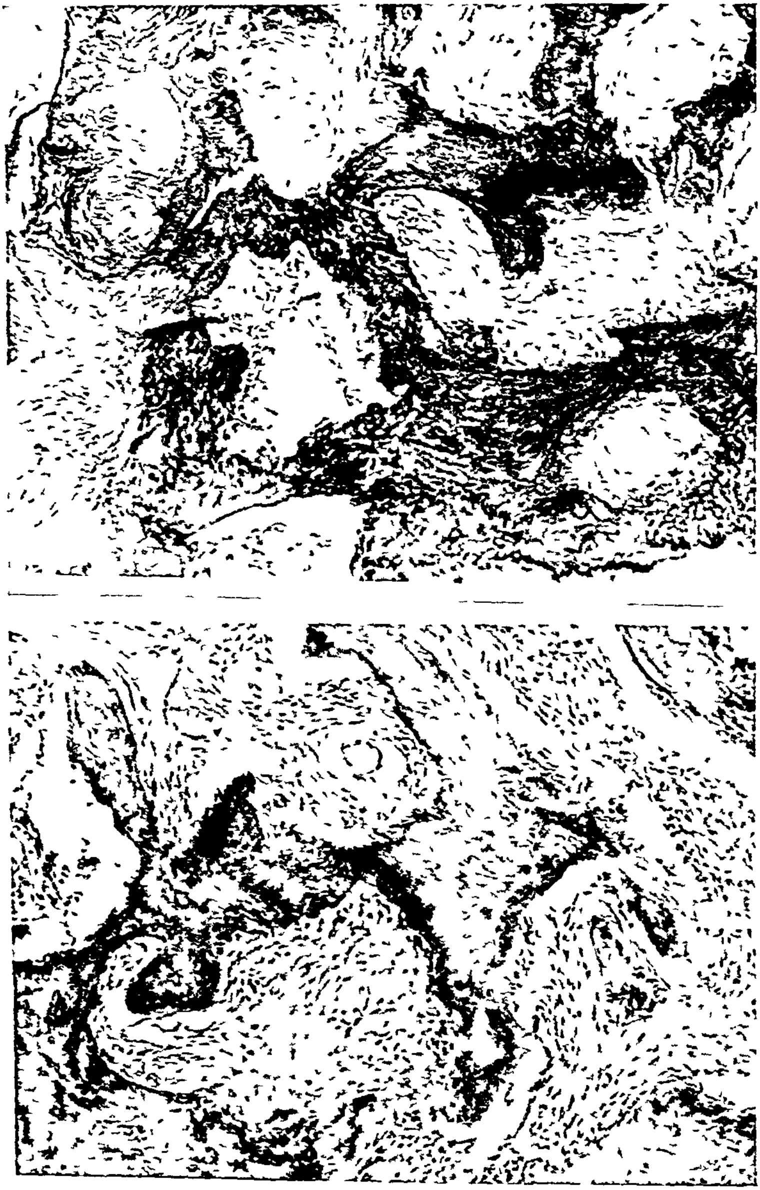

Fig 3 Photomicrographs showing fibrous dysplasia

no pneumatic spaces Skeletal survey showed no evidence of any other bone lesions Serum calcium and phosphorus were within normal limits In August, 1950, a bony mass was removed from the right ear, however, the ear drum could not be seen A lesion recurred and was removed in March, 1951, and a year later the ear was again completely obstructed by recurrent lesions The pathologist reported the bony tissue removed at these operations as compatible with osteoma

On June 27, 1956, the patient came into my office supported by two men and reported that he had had vertigo for four days on walking or sitting up but none on lying down He obviously had some labyrinthine irritation, but there were no new objective findings and X ray examination was essentially the same as before

July 3, 1956, right mastoidectomy was done by the postauricular approach The mastoid process was a smooth and massive structure The cortex was removed with a gouge and appeared to be bone of normal density for this structure The underlying bone structure had a peculiar granular texture, and showed no pneumatic spaces, it bled rather freely It was scooped out easily with a large curette, and three large cavities were found containing cholesteatoma and some fluid but no landmarks There was no escape of cerebro spinal fluid The matrix of the cholesteatoma was not removed One cavity of an estimated capacity of about 25 cc was created from these three cavities, and the deepest part of the cavity was estimated as two inches from the mastoid cortex, probably as deep as the internal auditory meatus in the posterior fossa The walls of the deepest cavity were bony, except that deeply and posteriorly the wall was densely membranous and non pulsating, but five months later and for a period of about a month, pulsation was observed in this area The cavity was packed and the posterior wound sutured

Microscopic examination of tissues by Dr A J Hertzog, Chief of Pathology at Touro Infirmary was reported *1* Cholesteatoma, *2* Fibrous dysplasia of the mastoid bone The slides were reviewed by Dr C E Dunlap, Chief of the Department of Pathology at Tulane University, and Dr Dunlap concurred in the diagnosis

The patient's postoperative course was good and he rapidly lost his vertigo After the wound cleared up, the right ear drum, which had been covered by the matrix of the cholesteatoma, was found intact and his hearing in the right ear showed a loss of about 30 db for the conversational frequencies At the present time examination of the right ear shows a large cavity which is dry and completely epithelialized, the ear drum is present and intact Vertigo and horizontal nystagmus to the right can be produced by lightly touching a spot in the depth of the cavity with a cotton applicator I suspect that this is from contact of the probe with the saccus endolymphaticus, but it may be that he has an undiscovered fistula of the posterior semicircular canal

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GEORGE M COATES, M D , Philadelphia, Pa —
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J W HAMPSEY, M D, Pittsburgh, Pa —
Current Concepts of Etiology and Management in Otolaryngic Allergy

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EXPERIMENTS ON TEMPORARY OBSTRUCTION OF THE INTERNAL AUDITORY ARTERY*†‡

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(By Invitation),
and
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(By Invitation),
Chicago, Ill

Certain types of sudden deafness are commonly considered to be the result of a vascular phenomenon in the inner ear and not infrequently associated with a considerable degree of recovery.

There is little factual information regarding these clinical observations, however, animal experiments indicate that the cochlea is exceedingly sensitive to its oxygen supply and when the oxygen supply is cut off electrical activity deteriorates within seconds[1] Experiments have shown that the vascular system of the inner ear is vital for the continuous supply of oxygen and metabolites Permanent obstruction of the inferior cochlear vein and its tributaries, and permanent occlusion of the internal auditory artery, produce rapid loss of function and characteristic histologic damage[2,3,4] How the

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†From the Section of Otolaryngology of the University of Chicago

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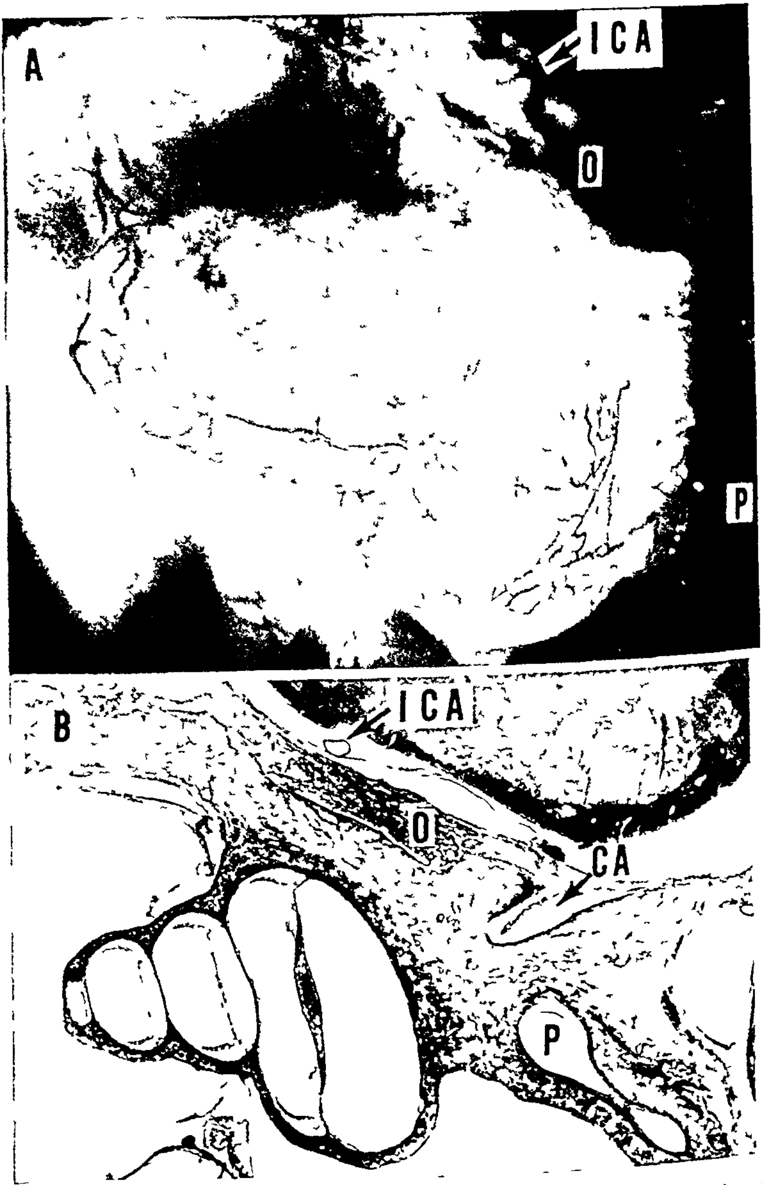

Fig 1 a—Enlarged photograph of the surgical field (O) showing the location of the inferior cerebellar artery (ICA) in relation to the cochlea b—Photomicrograph through a comparable area showing these relations on cross section The surgical defect (O) is filled with gelfoam CA is the cochlear aqueduct P is the posterior ampulla

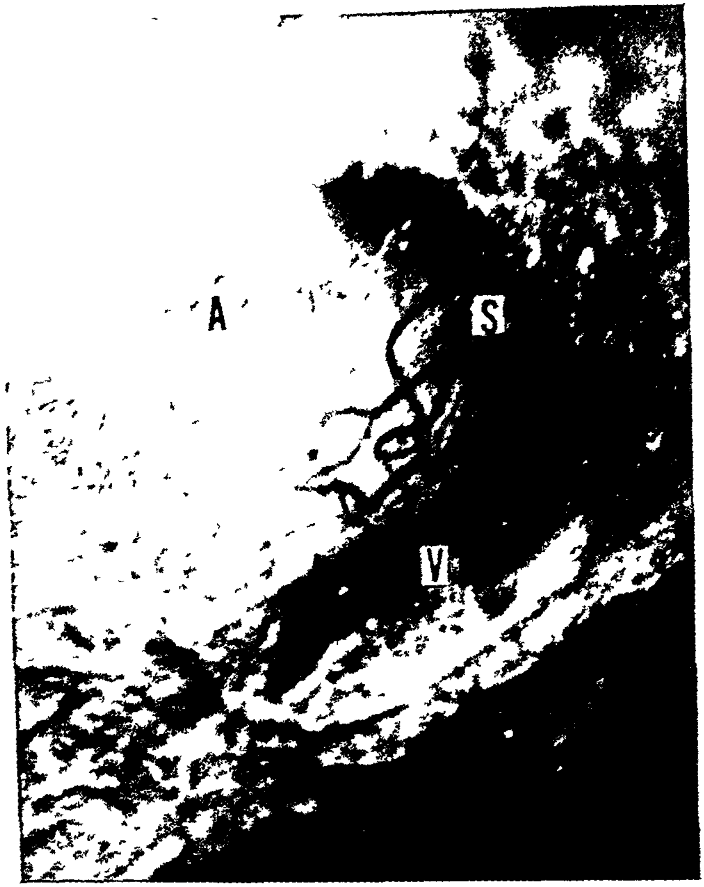

FIG. 2. Photograph through the microscope [illegible] exposed by [illegible] cochlear capsule. [illegible]

cochlea withstands temporary interruptions in its blood supply is not known. The surgical accessibility of the arterial branch to the inner ear in the guinea pig permitted an investigation on the effect of temporary obstruction of the artery (see Fig. 1). This was monitored continuously by observation of the cochlear blood flow in the apical turn, either by fenestrating or merely thinning the capsule. Obstruction was produced for various lengths of time by pressure with a probe mounted in a micromanipulator. Return of flow after release of pressure terminated a successful experiment. The details of the surgical approach have been described in a previous report A complete or almost complete cessation of blood flow in the cochlea was produced for one to 120 minutes and the results studied in three ways The changes in the exposed vascular bed in the fenestrated cochlea were studied with the aid of moving pictures taken at magnifications up to 275X (see Fig 2), the changes in function were assessed by cochlear microphonics and action potential recordings, and finally the inner ears were examined histologically Different animals with comparable times of obstruction were used for each series of observations In the groups studied histologically, the animals were kept alive for various periods of time up to three months In contrast to permanent obstruction, vestibular symptoms were minimal or absent in these animals recovering from temporary arterial obstruction

FINDINGS

A Changes in blood flow of the stria vascularis and spiral ligament The vascular pattern and the nature of the normal blood flow in the fenestrated apical area of the guinea pig cochlea has been described previously Regularity of flow and absence of diameter changes are striking When the probe is successfully applied on the ventral surface of the brain stem over the branch of the inferior cerebellar artery cochlear, blood flow stops almost immediately Sometimes a little pulsatile forward movement is observed with each inspiration, or a very slow continuous flow is seen With the micro-manipulator, further pressure usually succeeds in stopping the movement The slow flow in the strial vessels is the most easily stopped The blood cells usually remain in all the exposed vessels, however, with long obstruction some branches may become partly or completely free of cells, yet remain open and apparently filled with plasma "Critical closure" of arterioles with falling pressure, described by Burton, was not seen in our experiment even when pressure and flow were absent There is no evidence of clotting or dissolution of cells or movement of cells through the vessel wall There is little or no change in diameter of the vessels in the fenestra The blood becomes darker There is no sticking of blood cells to the vessel wall during short periods of obstruction With release of pressure , flow returns at once, and immediately after return of flow white blood cells sometimes adhere to the wall of the strial vessels but not to the wall of arteriole or arteriovenous arcade where flow is fast Larger numbers of white masses of various sizes flow through the vessels at this time Flow is much more rapid than normal for about 30 to 180 seconds As flow rate returns to normal, the vessels resume their normal appearance, but sometimes a branch of the stria may not resume flow With longer periods of obstruction, 30 to 60 mintes, changes in the vascular contents take place while the blood is stagnant, which are made evident with resumption of blood flow These are localized accumulations of blood cells and platelets adherent to the vessel wall and to each other With return of supernormal flow these elements are rapidly washed away as normal flow and a normal lumen is restored The restoration of normal blood flow, even after 60 minutes of obstruction, was the usual finding Occasionally flow did not return on release of the probe This was considered due to irreversible damage (thrombosis) of the vessel under the probe In this area, some changes in diameter due to local trauma were consistently observed Localized narrowing of the vessel was sometimes seen during manipulation, and dilation followed release of the pressure This dilation was considered to be responsible, at least in part, for the short but consistent supernormal flow seen at the fenestration site, however, there are many factors besides local trauma to be considered when blood flow is stopped in this manner The accumulation of platelets adhering to the vessel wall and to one another at the site of trauma has been observed by Zweifach,[5] and by Lutz, Fulton and Akers [6] Finally, the vessels were seen to become completely plugged with red and white cells Lutz, Fulton and Akers observe platelets throughout the field adhering to the vessel wall after 20 to 45 minutes of obstruction On release of obstruction circulating erythrocytes made channels through it, and platelet emboli were set free This corresponds to our observations in the cochlea Some of the white masses that flow into the field may arise from the site of pressure They also report that erythrocytes may remain unagglutinated even after many hours of stasis

Denny-Brown and Meyer[7] produced temporary (three and one-half minutes) cortical ischemia by occlusion of the middle cerebral artery and observed failure of the electrical activity within a few seconds, which recovered rapidly and completely on release of obstruction without damage to the vessels. They found that venous stasis after prolonged (15 to 30 minutes) ischemia could be reversed by elevating the blood pressure. When blood flow in the middle cerebral artery was stopped for longer periods irreversible damage to vascular endothelium led to infarction. They report that dilation, segmentation and stasis in the terminal venules was the first event following occlusion. This was followed by endothelial damage of the venules. They observed small microemboli lodging in the cortical vessels after prolonged occlusion and release of the middle cerebral artery. These were grey white and lodged temporarily in arteries of 50 to 150 micra in diameter. There was no arterial spasm at the site of lodgment. The microemboli were seen to move gradually to the terminal ramifications and in two to four minutes fragmented into minute particles and disappeared.

Zweifach notes vasodilation beyond the site of local trauma. We did not observe dilation in the region fenestrated during manipulation of the probe, but the slight dilation of the vessels in this terminal vascular bed, sometimes seen on return of blood flow, may have been due in part to the effect of anoxia and accumulation of CO_2 and acid metabolites on the vessel wall independent of the vessel changes at the point of obstruction. Bean and his associates[8, 9] have described this effect in intestinal vessels. In the cortex, Meyer, Fang and Denny-Brown[10] found that on release from obstruction, local cortical O_2 tension rises along with temperature and persists for one to five minutes depending upon the severity of ischemia, before returning to a steady state. This supernormal phase was considered due to local reactive hyperemia. Since increased local acidity of tissue (P_h) was recorded throughout this response, acidity rather than anoxia was considered the effective local dilator. Our observations on the cochlea during general asphyxia indicate that there is a gradual reduction in flow without change in vessel lumen or white blood cell sticking, however, occasional loss of red blood cells into the surrounding tissue is noted on recovery from asphyxia and here, too, flow returns to normal after going through a supernormal phase Control studies in our experiments indicated that blood pressure in the carotid was not affected by these manipulations on the artery, so that this was not a factor to be considered in explaining the supernormal flow immediately on release of obstruction In general, however, blood pressure has perhaps the most important single influence on the cerebral circulation Unlike the findings of Meyer[11 12] on obstruction of the middle cerebral artery, perivascular edema or diapedesis of blood cells was not seen in the fenestrated area No evidence of rupture of a blood vessel due to weakening of the vessel wall was found Meyer quotes Bayliss that pressure within the vessel may act as a stimulus to its smooth muscle cells With reduced intraluminal pressure these may relax to dilate and with increased pressure may contract to narrow the vessel We did not observe these changes, but realize that the cochlear vessels exposed by the fenestra have little or no smooth muscle

To summarize this portion of the experiment, one may say that cochlear blood flow may return to normal even after one hour of stasis, and that even the dislodged platelet masses appear to be washed through without plugging the vessels The blood flow rate is greater than normal immediately after release from obstruction The internal auditory artery appears to be the sole supply to the cochlea since pressure upon it results in complete cessation of blood flow

B Changes in function of the cochlea as revealed in evoked microphonics and action potentials The sudden and complete occlusion of the arterial supply to the inner ear produces profound and rapid changes in cochlear responses that give insight into the oxygen requirements of the cells generating them These findings, expressed as a function of time, may be compared with those in other tissues of the nervous system as reported by Gerard[13]

Method These experiments were carried out in 16 guinea pigs anesthetized with Dial® in urethane (0 5 cc per kilo body weight) The operative approach and insertion of silver

one-half minutes) cortical ischemia by occlusion of the middle cerebral artery and observed failure of the electrical activity within a few seconds, which recovered rapidly and completely on release of obstruction without damage to the vessels They found that venous stasis after prolonged (15 to 30 minutes) ischemia could be reversed by elevating the blood pressure When blood flow in the middle cerebral artery was stopped for longer periods irreversible damage to vascular endothelium led to infarction They report that dilation, segmentation and stasis in the terminal venules was the first event following occlusion This was followed by endothelial damage of the venules They observed small microemboli lodging in the cortical vessels after prolonged occlusion and release of the middle cerebral artery These were grey white and lodged temporarily in arteries of 50 to 150 micra in diameter There was no arterial spasm at the site of lodgment The microemboli were seen to move gradually to the terminal ramifications and in two to four minutes fragmented into minute particles and disappeared

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B Changes in function of the cochlea as revealed in evoked microphonics and action potentials The sudden and complete occlusion of the arterial supply to the inner ear produces profound and rapid changes in cochlear responses that give insight into the oxygen requirements of the cells generating them These findings, expressed as a function of time, may be compared with those in other tissues of the nervous system as reported by Gerard[13]

Method These experiments were carried out in 16 guinea pigs anesthetized with Dial® in urethane (0 5 cc per kilo body weight) The operative approach and insertion of silver

one-half minutes) cortical ischemia by occlusion of the middle cerebral artery and observed failure of the electrical activity within a few seconds, which recovered rapidly and completely on release of obstruction without damage to the vessels They found that venous stasis after prolonged (15 to 30 minutes) ischemia could be reversed by elevating the blood pressure When blood flow in the middle cerebral artery was stopped for longer periods irreversible damage to vascular endothelium led to infarction They report that dilation, segmentation and stasis in the terminal venules was the first event following occlusion This was followed by endothelial damage of the venules They observed small microemboli lodging in the cortical vessels after prolonged occlusion and release of the middle cerebral artery These were grey white and lodged temporarily in arteries of 50 to 150 micra in diameter There was no arterial spasm at the site of lodgment The microemboli were seen to move gradually to the terminal ramifications and in two to four minutes fragmented into minute particles and disappeared

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wire electrodes in the first turn of the cochlea have been described elsewhere[14,15] The surgical approach for the vascular supply of the inner ear and technique of occlusion have been described previously The sound stimuli used in these experiments were 8,000 or 10,000 cycle tone pips The intensity was at high level, near the point of maximum response of cochlear microphonics The duration of the tone-pip stimulus was about 1 millisecond or less Cochlear responses were photographed on a dual beam oscilloscope before, during, and after occlusion of the vascular supply to the inner ear The time of each occlusion varied from one minute to 65 minutes In 14 animals only one period of occlusion was given, and in two others the procedure was repeated two or three times

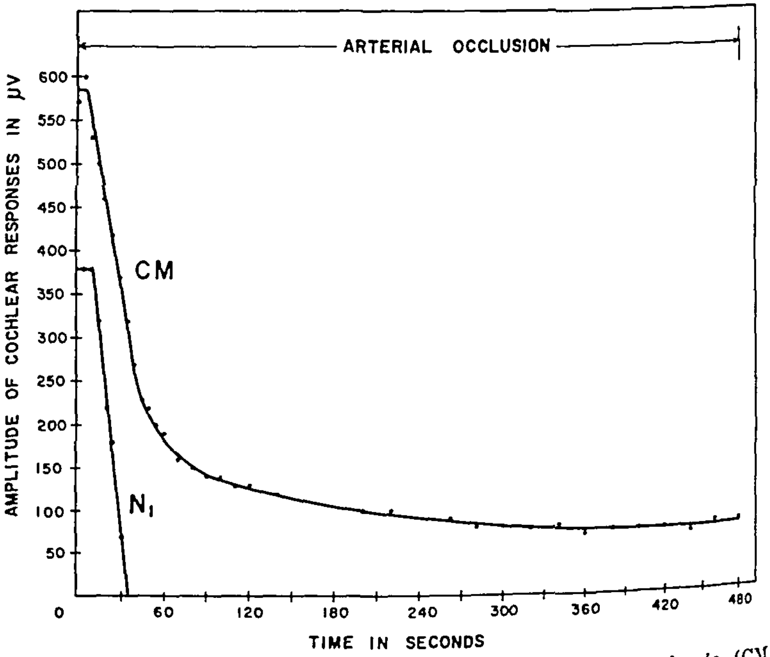

Fig 3 Graph showing changes in Neural (N_1) and microphonic (CM) response of the cochlea after arterial obstruction

During occlusion, the blood flow in the cochlea was monitored continuously by observing the radiating arteriole through the thinned capsule in the apex

RESULTS

A *Survival Time*

The survival time is defined as the interval between the onset of occlusion and the instant the responses disappear According to Gerard, it is an index of the oxidizing reserve, energy provided by other reactions, such as glycolysis, and metabolic rate

There was an interval of about ten seconds from the beginning of occlusion to the first signs of depression in cochlear responses Decay of the neural components (N_1 and N_2) seemed to precede that of the cochlear microphonics (CM) by a few seconds The decay of all responses closely followed a linear function of time, but at different rates Action potentials decayed faster than CM This observation is illustrated in Fig 3, in which the amplitude of CM and N_1 of a representative animal (see Fig 1), is plotted as a function of time

TABLE I

SURVIVAL TIME OF COCHLEAR RESPONSES

Cochlea (clamping trachea)		Cochlea (arterial occlusion)		CNS (arterial occlusion)	
CM	80 120 sec	CM	75 85 sec	Cerebellar gray	10 20 sec
N_1	120 sec	N_1	30 45 sec	Cerebral cortex	14-15 sec
		N	20 45 sec	Corona radiata	20 25 sec
				Medulla	30 120 sec

The survival time of cochlear responses are summarized in Table I, which also includes the survival time of cochlear responses as determined by clamping the trachea and the survival time of special areas of the central nervous system as determined by occlusion of the vascular supply

The results clearly indicate that the sensitivity of cochlear primary neurons to oxygen deprivation is close to that of nervous tissue in the central nervous system The generators of the oxygen dependent portion of cochlear microphonics (hair cells of organ of Corti) are twice as resistant to oxygen lack as the generators of action potentials (primary neurons) The information does not tell whether the depression of cochlear microphonics is due to impairment of hair cells or decay of the DC resting potential in the cochlear partition After the investigations of Bekesy[16] and Davis, et al [17] we may assume that the depression of CM may be due to metabolic impairment of both hair cells of the organ of Corti and the stria vascularis

The appraisal of survival time clearly indicates that the oxidative reserve within the cochlea is quite small and/or the oxygen requirements of the generators of electrical activity is rather large Almost immediate drop in available oxygen in cerebral tissues after vascular occlusion is shown with the polarographic method [7, 18] Rapid drop in available oxygen in the cochlea produced by nitrogen breathing has also been demonstrated [19]

The longer survival times obtained by clamping the trachea (see Table I) were due to the oxygen supplied by the circulating blood

RECOVERY TIME

The recovery time is defined as the interval from the end of occlusion to the first signs of recovery of responses According to Gerard,[13] *this time is an index* of the speed of physico-chemical reconstruction of cells

In our series, several animals showed no recovery of either function or circulation when the occlusion was discontinued This suggested that the procedure of compressing the vascular supply might produce damage to both nerve fibers and blood vessels Determination of recovery time and time required for complete recovery of cochlear responses were ascertained in those animals which showed reversal of both function and circulation Because of uncertainties the quantitative determination will be postponed for further inevstigation In the present report only some qualitative aspects are presented

In general, short periods of occlusion (less than five minutes) were followed in a few seconds by recovery of cochlear microphonics followed by recovery of the action potentials As time of occlusion was prolonged the recovery time of CM was little affected, while that of N_1 became longer

Complete recovery of cochlear responses was observed after occlusions of less than eight minutes Above 30 minutes of occlusion neither CM nor N_1 seemed to reach even 50 per cent of the reference amplitude Although we do not have observations on occlusions between eight and 30 minutes, we may infer that severe depression of cochlear function may follow complete interruption of the vascular supply of about 30 minutes The question whether this impairment is permanent or transitory remains to be investigated Recent observations by Meyer on occlusion of the middle cerebral artery indicate that permanent impairment of motor function required at least 50 minutes of occlusion If cortical oxygen tension was below 20 per cent for longer than one hour, infarction regularly occurs Shorter periods of occlusion produced temporary paralysis that could be aggravated by reducing the systemic blood pressure The electroencephalogram followed the changes in circulation closely, but functional recovery lagged behind restoration of blood flow, oxygen tension, and the electroencephalogram

Another feature of recovery which needs further investigation is the supernormal response of neural components immediately following a short period of occlusion The supernormal response of action potentials paralleled a rather large increase of the summating potential This study may be important for the understanding of present concepts in cochlear physiology The supernormality of electrical activity corresponds to that of supernormal blood flow recorded in the moving pictures Meyer et al[1-] found a similar effect on the available oxygen in the cortex on release of arterial obstruction as revealed by the polarographic method, and interpreted this as reflecting both increased blood flow and reduced oxygen consumption of the nervous tissue

Our observations indicate that the generators of cochlear microphonics possess a ready mechanism for physico-chemical of the oxygen dependent portion of cochlear microphonics (hair cells of organ of Corti) are twice as resistant to oxygen lack as the generators of action potentials (primary neurons) The information does not tell whether the depression of cochlear microphonics is due to impairment of hair cells or decay of the DC resting potential in the cochlear partition After the investigations of Bekesy[16] and Davis, et al [17] we may assume that the depression of CM may be due to metabolic impairment of both hair cells of the organ of Corti and the stria vascularis

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Our observations indicate that the generators of cochlear microphonics possess a ready mechanism for physico-chemical reconstruction, while that of the neural components seemed to be slow and easily damaged

REVIVAL TIME

The revival time is defined as the maximum duration of occlusion after which responses can return According to Gerard,[1] it is an index of rate of occurrence of changes due to proteolysis, accumulation of metabolites and the like

Our observations, though not yet completed, indicate that the survival time of CM is about 60-65 minutes and that of action potentials about 50 minutes

C *Histological Findings* The ears of 50 animals were prepared for histological examination following temporary arterial obstruction These included obstructions of 3, 5, 10, 15, 20, 30, 45, 60 and 120 minutes Definite histological changes can be produced by temporary obstruction of the internal auditory artery These changes are unlike those produced by permanent venous obstruction or permanent arterial obstruction In general, the longer the obstruction the more severe the damage Because of technical difficulties, obstruction was sometimes incomplete This resulted in variation in the degree of cell damage within the group with similar durations of obstruction Interruption of blood flow for only a few minutes does not produce cell changes in the cochlea With obstruction of five minutes or more, spotty small lesions appear The reason for this distribution of damage is not evident The cochlear structures are much more vulnerable than the vestibular Within the cochlea, the hair cells, cells of the limbus spiralis, and the spiral ganglion cells are the principal structures involved Hair cell lesions may lead to spiral ganglion cell degeneration if the animal is allowed to survive for over two weeks This type of secondary change in the spiral ganglion cells is evident in short (5-15 minutes) arterial obstructions The independent response of these ganglion cells, however, is apparent in short term experiments before secondary degeneration can take place Thus, in animals sacrificed within a few days, ganglion cells show changes only after arterial obstructions of 30 minutes or more Hair cell damage is scattered throughout the cochlea but varies from animal to animal and is not extensive even after one hour obstruction The basal turn is perhaps more commonly affected When the arterial supply is permanently obstructed either by trauma from the probe or direct coagulation of the vessel, disintegration of the cochlea sets in almost at once, and continues to complete necrosis in less than 24 hours In contrast, the lesions produced by temporary arterial obstruction are very small and non-progressive In the short obstructions (under 15 minutes) the outer hair cells are more often affected than the inner hair cells and supporting cells With longer obstructions, both inner and outer hair cells and pillar cells are affected, however, chronic venous obstruction also produces outer hair cell damage These findings suggest that in general the outer hair cells are more vulnerable when blood flow is impaired. In marked contrast to the findings in chronic venous obstruction atrophy of the stria and spiral ligament was minimal Hemorrhage, spiral ligament degeneration and pigment cell migration were completely absent Similar to the findings in chronic venous obstruction and permanent arterial obstruction, endolymphatic hydrops or collapse of the cochlear duct did not occur The histological technique was adequate to show this pathology, and in a few instances definite labyrinth hydrops was seen in the control ear, associated with severe middle ear infection When the vestibular part of the labyrinth was involved (obstruction of one hour or longer) the hair cells in their end-organs were most susceptible to damage There were no changes visible in the endolymphatic sac Since blood flow in these areas was not examined, its relation to vestibular cell damage cannot be clearly defined

Representative changes are illustrated in Figs 4 to 10

Our findings of limited histological damage in the inner ear after one hour of arterial obstruction may be compared with those of Meyer [20] He reports that infarction of the cortex occurs when the local oxygen tension falls below 20 per cent for more than one hour

The recognition of significant histological changes in the labyrinth following temporary obstruction of the arterial reconstruction, while that of the neural components seemed to be slow and easily damaged

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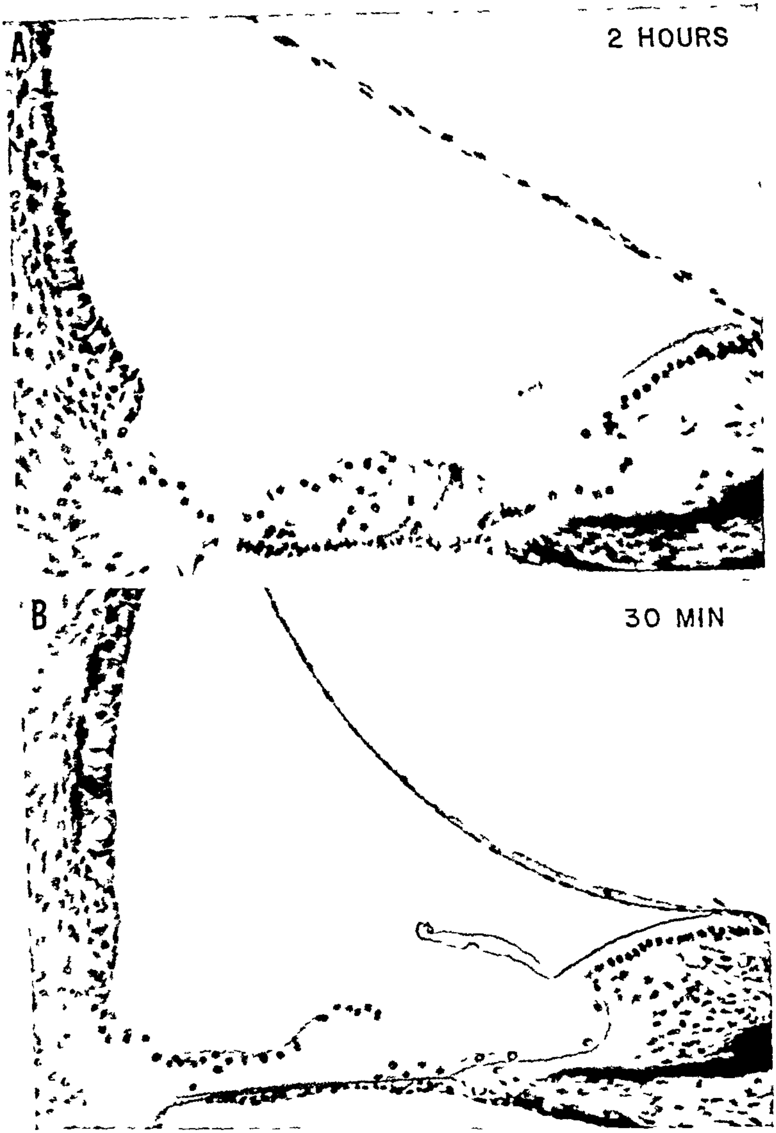


Fig 5 a—Loss of outer and inner hair cells and limbus cells four days after two hours of arterial obstruction b—Loss of sensory and supporting cells with normal stria three months after 30 minutes of arterial obstruction

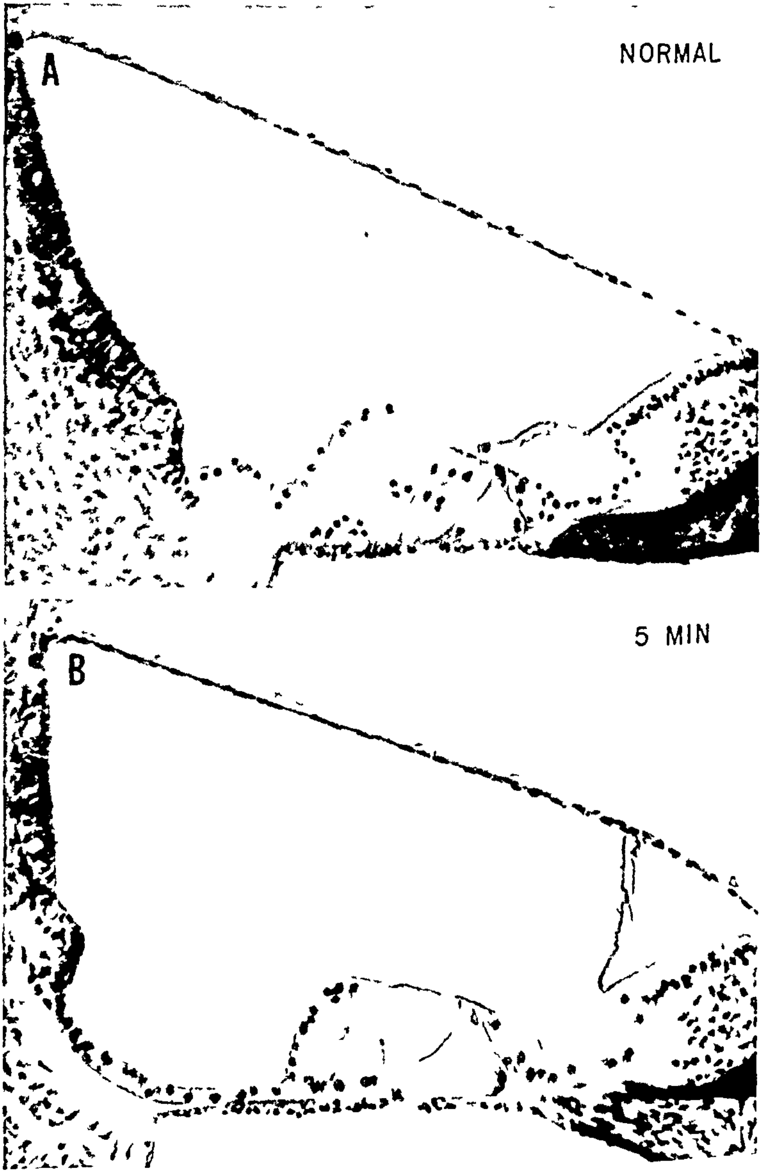


Fig 4 a —Normal cochlear duct b —Loss of outer hair cells 45 days after five minutes arterial occlusion

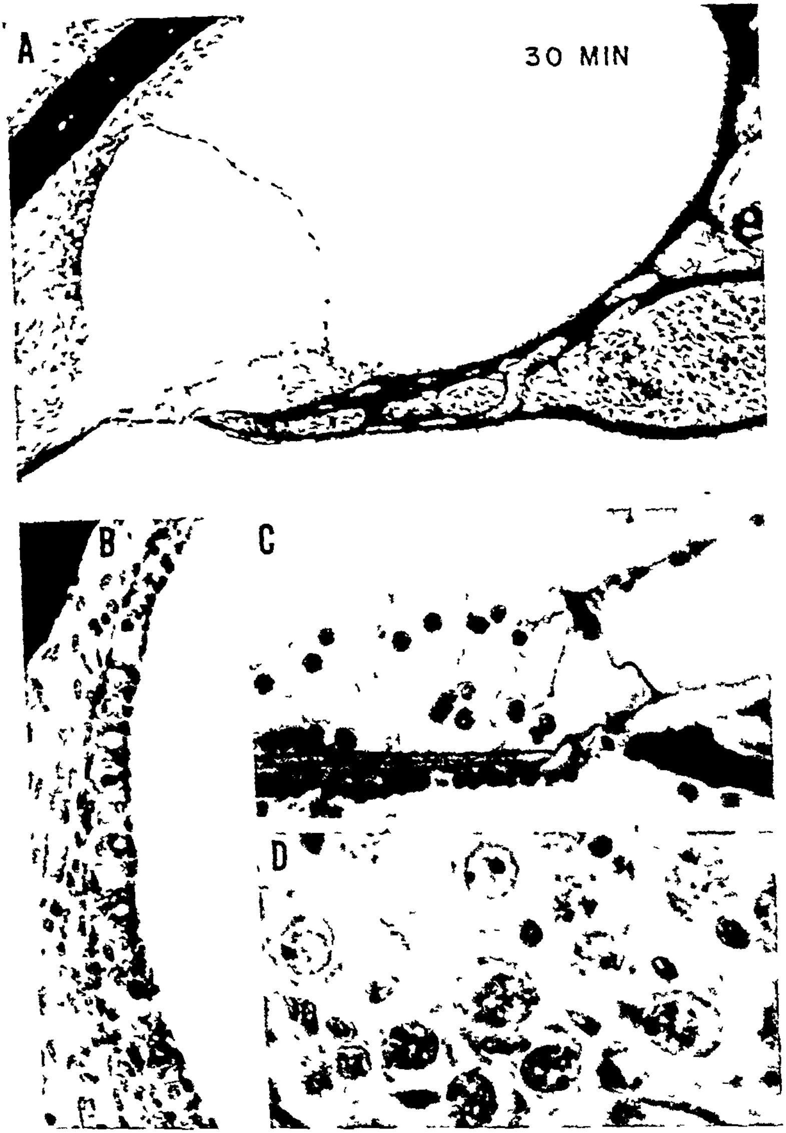


Fig 7 a—Inner and outer hair cell damage one day after 30 minutes arterial obstruction (higher power in b c and d) b—Stria unaffected by this temporary obstruction c—Hair cells in organ of Corti seen in a d—Adjacent spiral ganglion cells show minimal changes

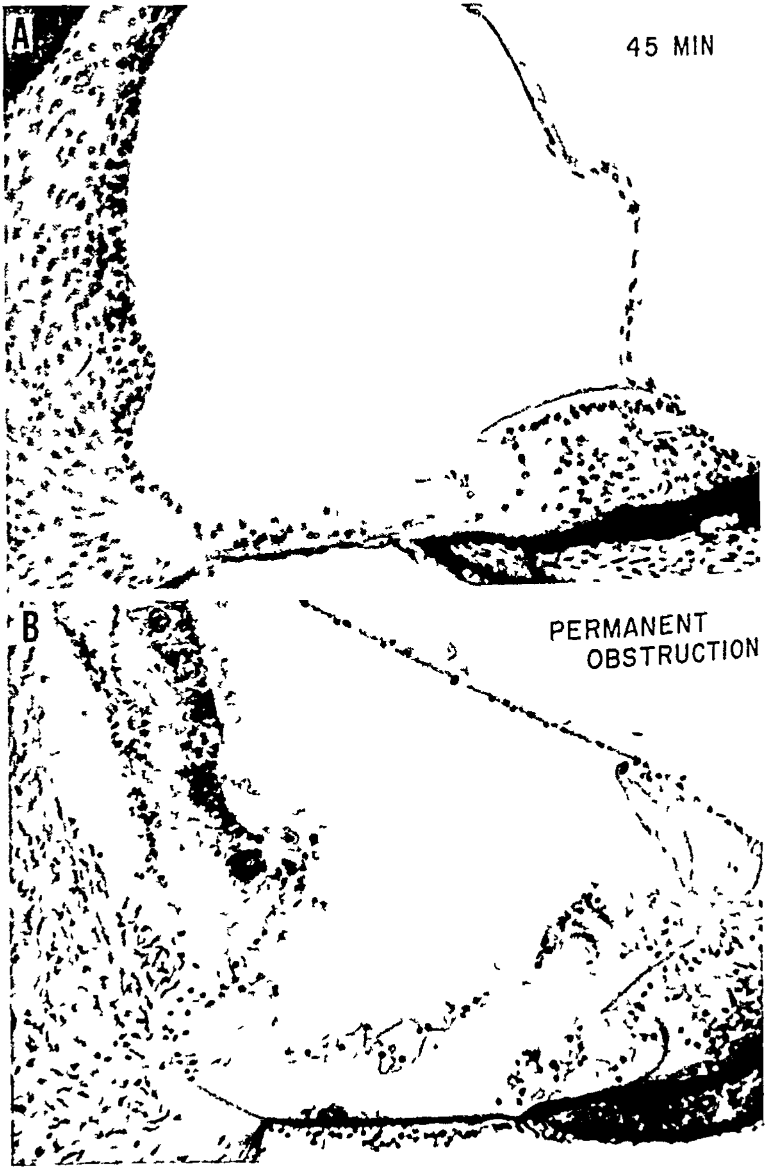


Fig 6 a—Loss of organ of Corti and atrophic stria one month after 45 minutes arterial obstruction b—Necrosis of stria and end organ one day after complete and irreversible obstruction

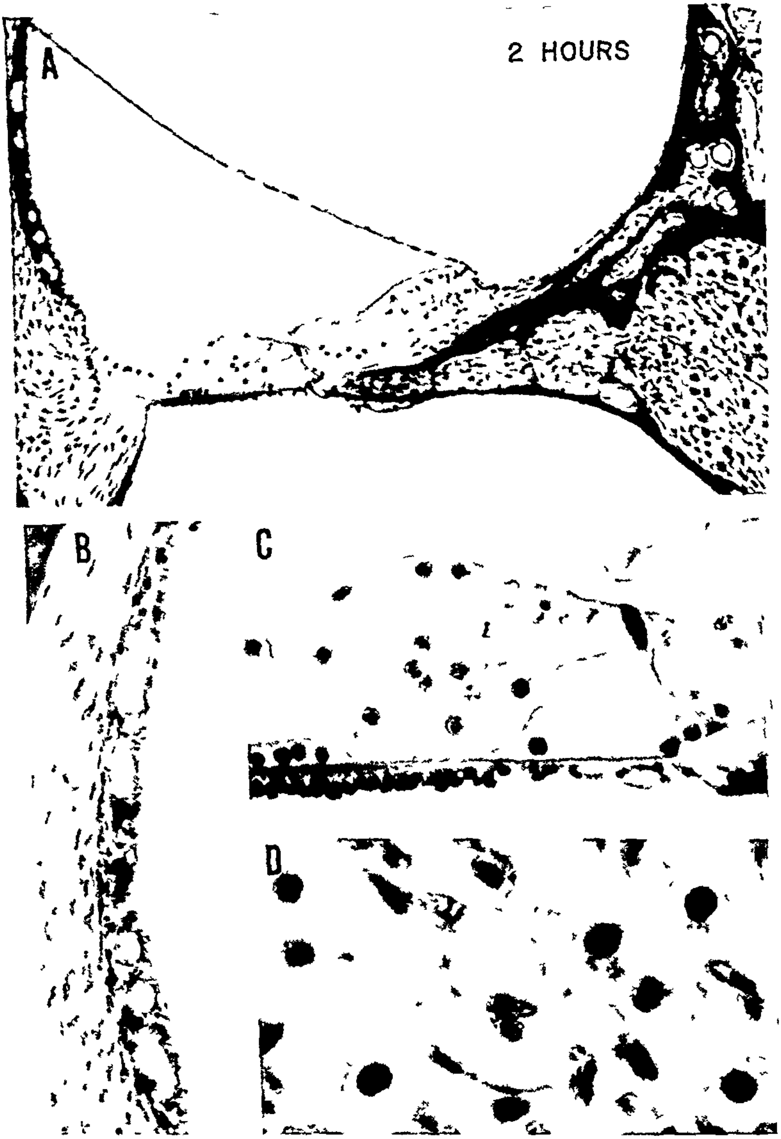


Fig 9 a—Hair cell spiral ganglion and strial changes one day after two hours of arterial obstruction (higher magnifications in b c and d) b—Vascular changes in stria c—Sensory cell damage in organ of Corti d—More advanced ganglion cell lesion than in Fig 6

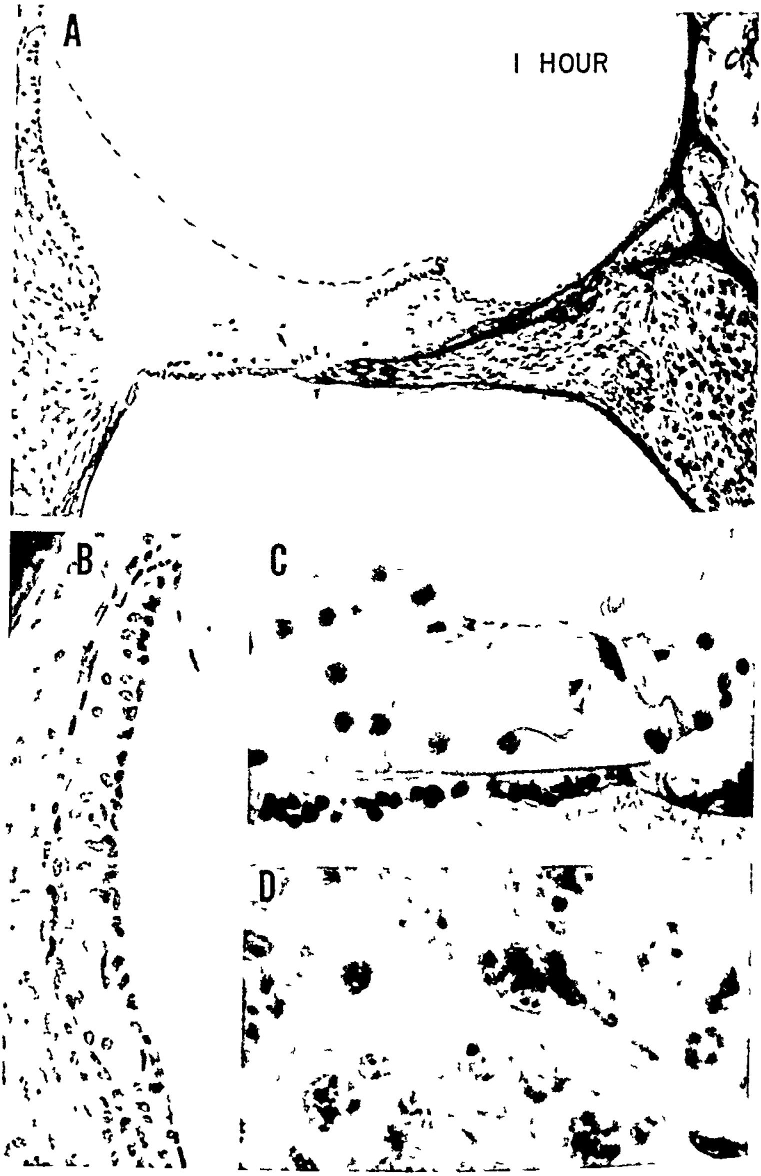
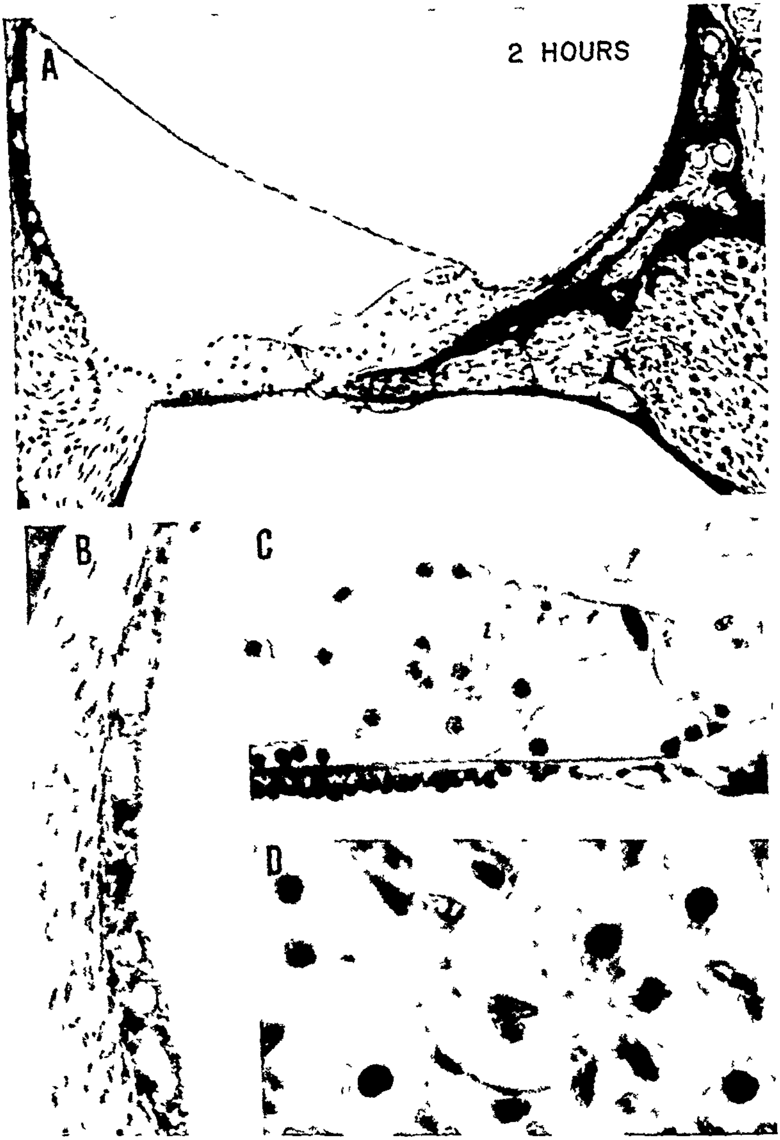


Fig 8 a—Sensory cell and spiral ganglion cell damage one day after one hour arterial obstruction (higher magnifications in b c d) b—Minimal edema of the stria vascularis c—Details of hair cell damage d—Early spiral ganglion cell changes



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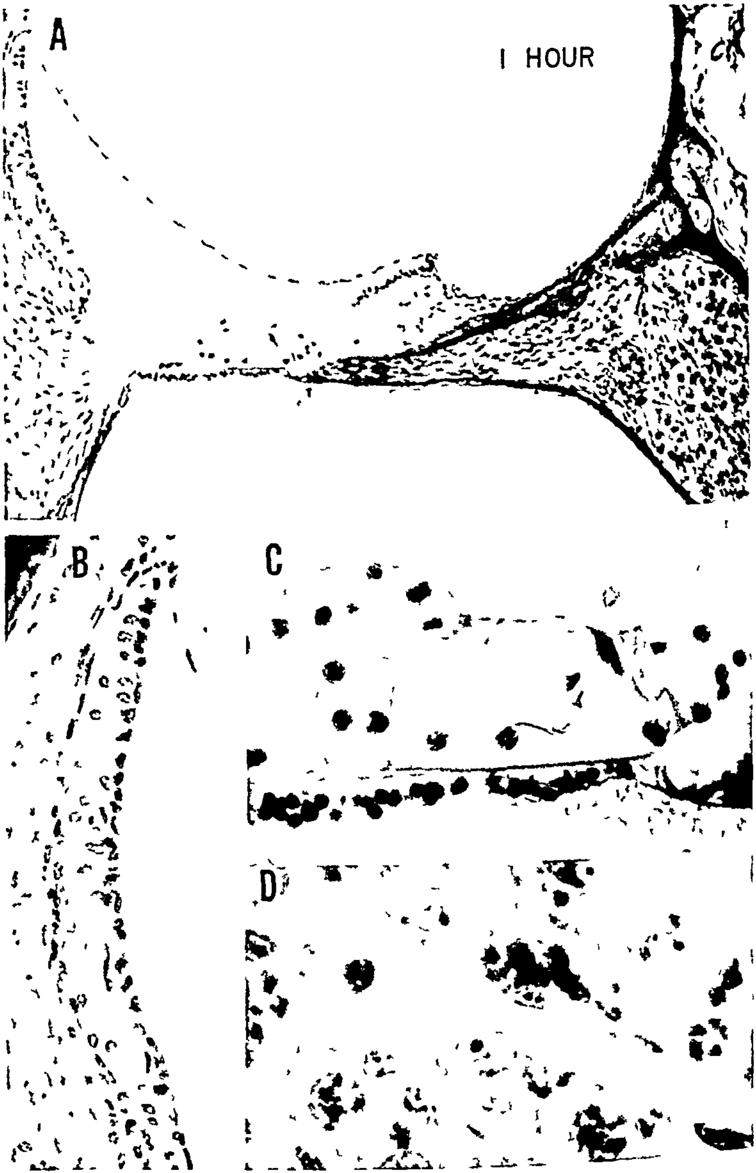

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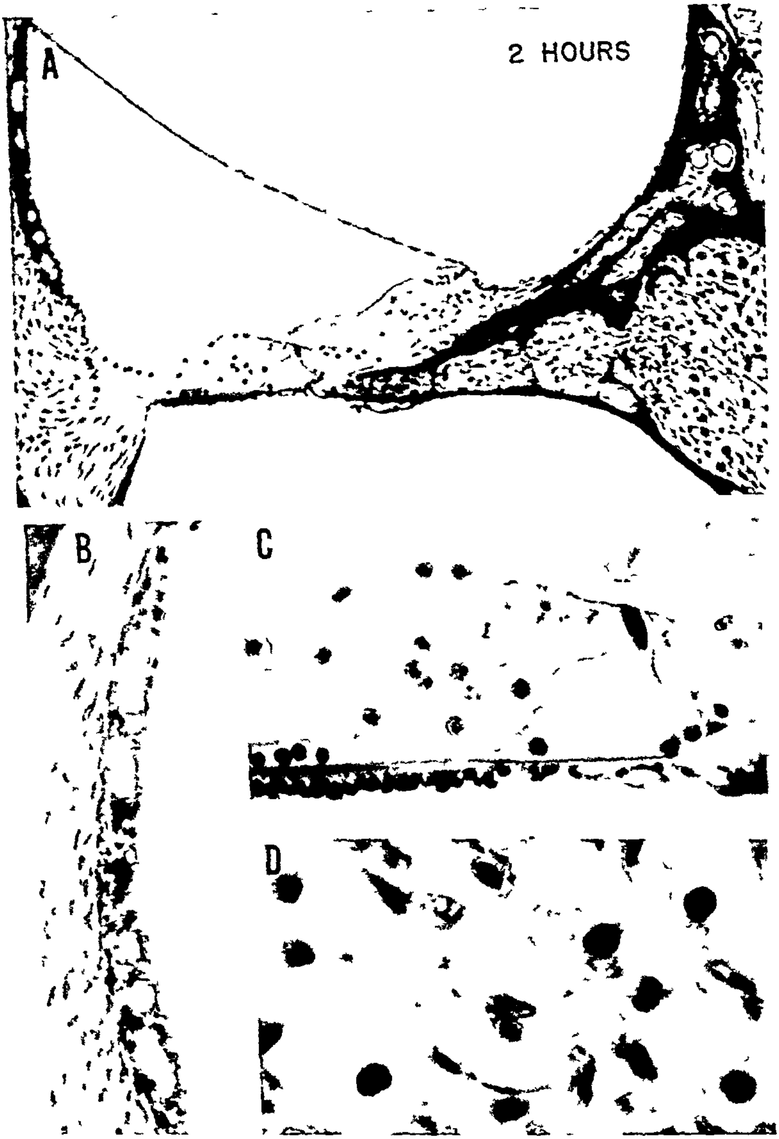

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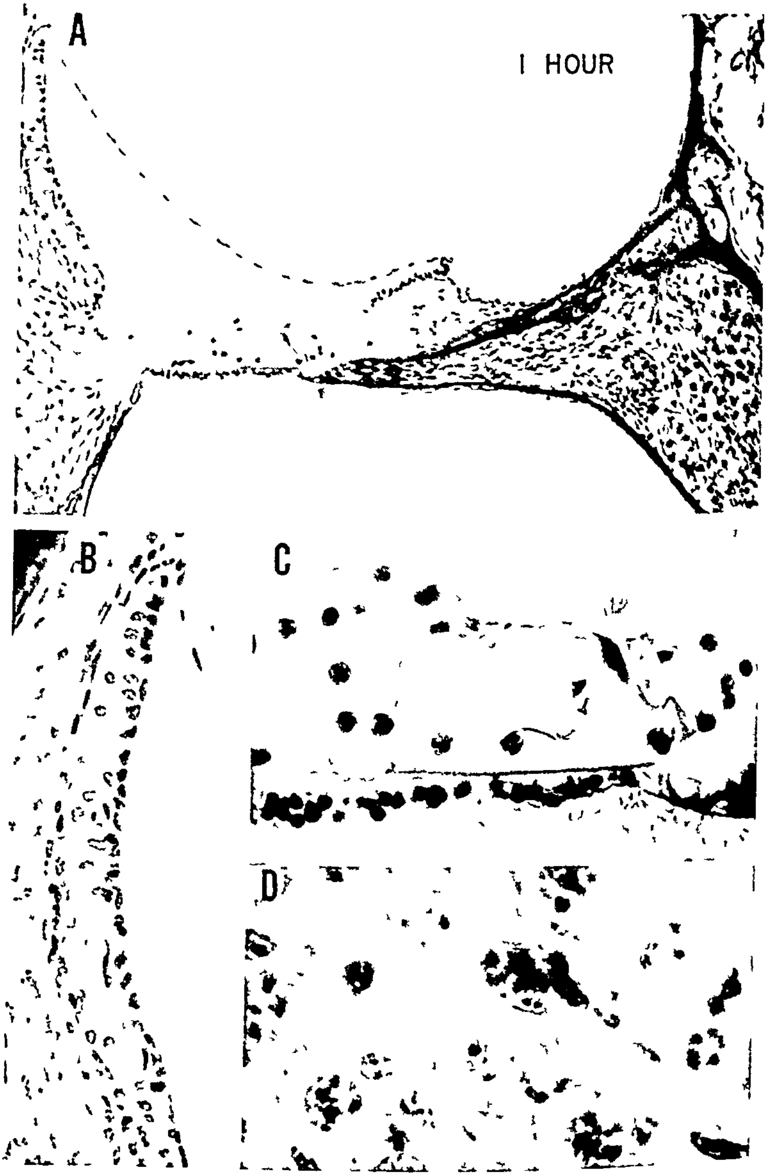

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supply was aided by the presence of the unoperated ear on the same slide for comparison, furthermore, previous studies on permanent venous and arterial obstruction of the labyrinth revealed characteristic histological changes Rapid necrosis of the labyrinth seen in sections from permanent arterial obstruction was in marked contrast to smaller lesions more slowly developing and associated with labyrinth hemorrhage, seen in chronic venous obstruction This permitted the separation of unsatisfactory experiments where either or both of the above vascular lesions resulted from the surgical procedure Because of the surgical approach, permanent damage to the venous outflow or to the arterial supply to the labyrinth occasionally resulted This was usually recognized at the time of operation by observing changes in blood flow and diameter of the radiating arteriole through the capsule bone, and fitted in with these characteristic histological changes subsequently found

Another problem that arose in the histological evaluation of this vascular lesion, was the unexpected trauma to the VIIIth nerve trunk that occasionally followed manipulation with the probe In this series of experiments it was possible to find a group with uncomplicated nerve damage that showed degenerative changes extending through the spiral ganglion to the end-organ typical of nerve trauma These degenerative changes were apparent only when the animal was kept alive at least two weeks For this resaon, animals that were sacrificed before this period of time had elapsed and with various durations of arterial obstruction, were the most satisfactory in evaluating the significant changes following the vascular lesion

GENERAL SUMMARY

It is possible to interrupt the arterial supply to the inner ear by pressure with a probe over the internal auditory artery On release of pressure, flow returns to normal after first going through a supernormal period Blood flow may return to normal even after one hour of obstruction without visible permanent change in the blood vessels or their surroundings The short period of supernormal flow is probably due to tem-

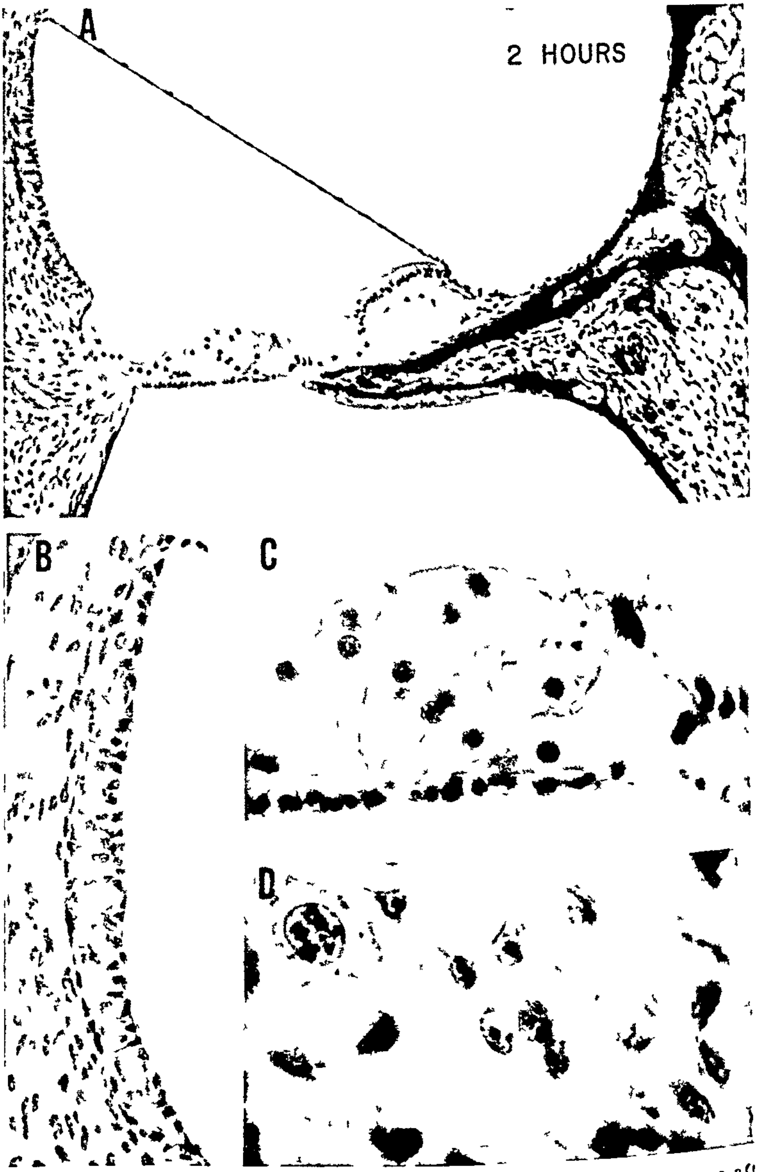

Fig 10 a —Hair cell limbus and ganglion cell damage four days after two hours of arterial obstruction (higher power in b c and d) b —Normal stria c —Inner and outer hair cell lesion d —Dissolution of spiral ganglion cells supply was aided by the presence of the unoperated ear on the same slide for comparison, furthermore, previous studies on permanent venous and arterial obstruction of the labyrinth revealed characteristic histological changes Rapid necrosis of the labyrinth seen in sections from permanent arterial obstruction was in marked contrast to smaller lesions more slowly developing and associated with labyrinth hemorrhage, seen in chronic venous obstruction This permitted the separation of unsatisfactory experiments where either or both of the above vascular lesions resulted from the surgical procedure Because of the surgical approach, permanent damage to the venous outflow or to the arterial supply to the labyrinth occasionally resulted This was usually recognized at the time of operation by observing changes in blood flow and diameter of the radiating arteriole through the capsule bone, and fitted in with these characteristic histological changes subsequently found

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The cochlear function as reflected in microphonic and action potentials is profoundly depressed within 60 seconds after complete interruption of the arterial supply but may return to normal even after eight minutes of complete obstruction If blood flow stops for over 30 minutes, there is only partial recovery of electrical responses

Histological changes in the labyrinth are produced by temporary arterial obstruction The external hair cells and the ganglion cells of the cochlea are particularly vulnerable, while the vestibular end-organs are least affected Even one hour of obstruction produces minimal changes throughout the cochlea These changes are unlike those produced by permanent obstruction of the internal auditory artery or permanent obstruction of the inferior cochlear vein and its tributaries Endolymphatic hydrops does not follow temporary obstruction of the internal auditory artery

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COURSE IN AUDIOLOGY AND OTOLOGY

The program of the II Audiology and Otology Course which the Departmento of O R L of Hospital San Jose of Bogota, Colombia, is organizing for the month of August, 1959 includes the names of many otorhinolaryngologists of Colombia, Venezuela and Ecuador The price of this course is $1,000 and is limited to 20 matriculants The course in audiology only is $500 00 The closing date for registration is July 10, 1959 For further details write Jorge Garcia Gomez, Head of the E N T Department Hospital, San Jose, Bogota, Colombia porary dilation of the internal auditory artery and its large tributaries on the basis of trauma and local anoxia

The cochlear function as reflected in microphonic and action potentials is profoundly depressed within 60 seconds after complete interruption of the arterial supply but may return to normal even after eight minutes of complete obstruction If blood flow stops for over 30 minutes, there is only partial recovery of electrical responses

Histological changes in the labyrinth are produced by temporary arterial obstruction The external hair cells and the ganglion cells of the cochlea are particularly vulnerable, while the vestibular end-organs are least affected Even one hour of obstruction produces minimal changes throughout the cochlea These changes are unlike those produced by permanent obstruction of the internal auditory artery or permanent obstruction of the inferior cochlear vein and its tributaries Endolymphatic hydrops does not follow temporary obstruction of the internal auditory artery

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disease in the middle ear, mastoid, attic and eustachian tube regions and provide a quantitative evaluation of auditory function The ear should be thoroughly cleaned with a small suction tip, inspected, and possibly probed under visual magnification An attempt should be made to evaluate the functional status of the ossicles and ear drum and the condition of the middle ear mucosa Inspection under magnification should determine the presence and extent of squamous cell epithelium in the middle ear and epithelialized tracts extending into the antrum and attic The eustachian tube can be tested for patency by the Valsalva technique using controlled air pressure (from 30 to 80 mm mercury) while inspecting the middle ear with magnification (see Fig 1), thus, perforations and false membranes can be studied and hidden purulent material can be detected The sound probe test is useful in evaluating the functional integrity of the ossicular chain[3] The crossed stapedial reflex may be helpful in determining the mobility of the stapes Roentgenograms of the

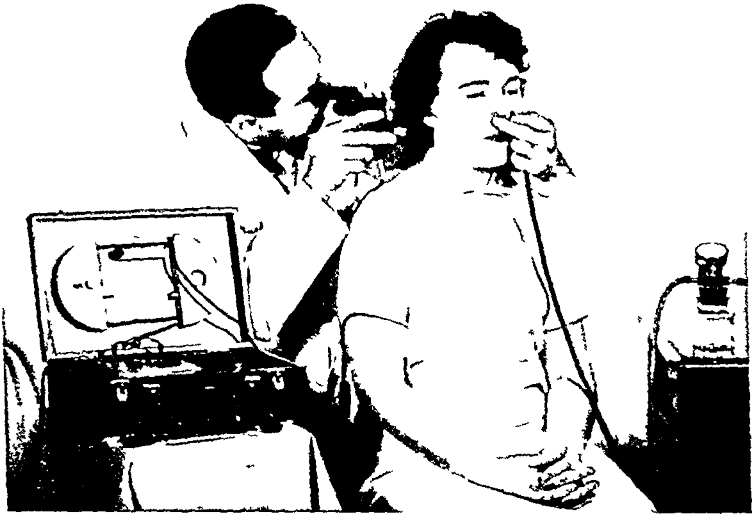

Fig 1 The combined use of controlled inflation and inspection under magnification is essential for preoperative examination and for postoperative evaluation The Hallpike microscope used in conjunction with the Senturia inflator has been satisfactory in our experience

TYMPANOPLASTY[*][†]

HAROLD F SCHUKNECHT, M D,
and
STANLEY OLEKSIUK, M D, (By Invitation),
Detroit, Mich

INTRODUCTION

The radical mastoid operation as commonly performed in the past often resulted in further hearing loss and, therefore, created among both otologist and patient a dislike for this operation Consequently, many surgeons refused to "clean out" the tympanic cavity and so were able to preserve a practical hearing level in some cases These conservative operations consisted of removing disease from the attic, antrum or mastoid and sometimes from the mesotympanum while preserving mucosa, ossicles and any remaining tympanic membrane An anatomical mechanism providing a sound pressure difference at the windows was sometimes established, quite inadvertently, by these methods This conservative approach often failed, however, because of recurrence of cholesteatoma and continued suppuration

With the aid of antibiotics and the operating microscope, associated with a better understanding of skin grafting techniques and middle ear physiology, surgery for the correction of suppurative middle ear disease can be performed with a better opportunity of inactivating the disease while preserving or improving the hearing We are indebted, of course, to Wullstein[1] and Zollner[2] for providing us with refinements in tympanoplastic technique

PREOPERATIVE EXAMINATION

The preoperative examination must assess the extent of

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[*] Presented at the Meeting of the Eastern Section of the American Laryngological Rhinological and Otological Society New York City Jan 9 1959

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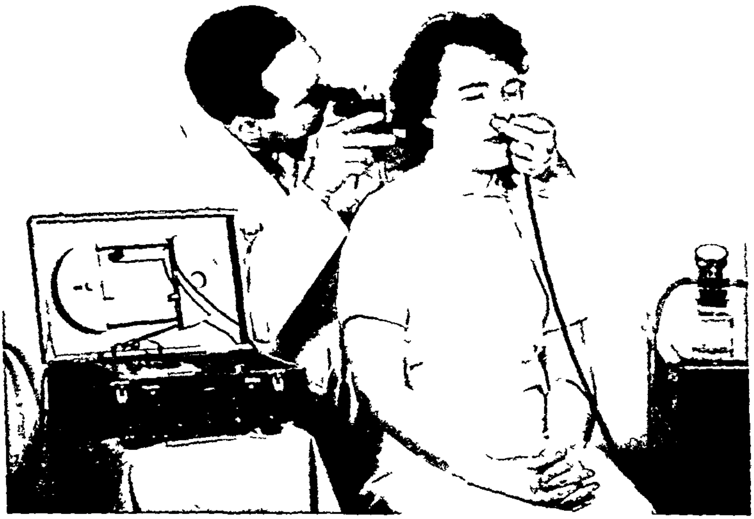
disease in the middle ear, mastoid, attic and eustachian tube regions and provide a quantitative evaluation of auditory function The ear should be thoroughly cleaned with a small suction tip, inspected, and possibly probed under visual magnification An attempt should be made to evaluate the functional status of the ossicles and ear drum and the condition of the middle ear mucosa Inspection under magnification should determine the presence and extent of squamous cell epithelium in the middle ear and epithelialized tracts extending into the antrum and attic The eustachian tube can be tested for patency by the Valsalva technique using controlled air pressure (from 30 to 80 mm mercury) while inspecting the middle ear with magnification (see Fig 1), thus, perforations and false membranes can be studied and hidden purulent material can be detected The sound probe test is useful in evaluating the functional integrity of the ossicular chain[3] The crossed stapedial reflex may be helpful in determining the mobility of the stapes Roentgenograms of the



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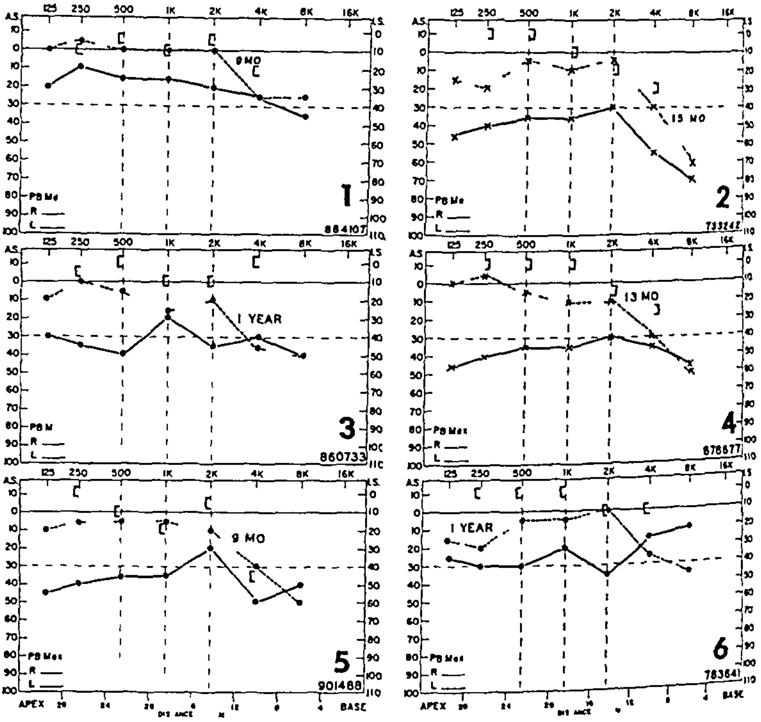


Fig 2 Examples of successful Type I tympanoplasties We have plotted the frequencies on the abscissas of the audiograms in accordance with their approximate spacial distribution along the Cochlear duct thus the low frequencies are somewhat crowded at the left end of the scale Distance along the Cochlear duct is indicated in millimeters at the bottom of the charts The ordinate on the left shows hearing loss in decibels by the American Standard and on the right by the International Standard the latter corresponding closely to the current British Standard The American Standard is based on a U S Public Health Service population survey and is based on average normal hearing whereas the International (or British) Standard is based on the median value for the hearing of well motivated young adults otologically normal and carefully tested

temporal bone may reveal gross changes but are of little help in revealing pathological changes which are of technical importance in tympanoplasty

Auditory tests should establish not only the pure tone thresholds for bone and air but the discrimination score as well If the predicted value of tympanoplasty surgery is insignificant (*e g*, severe bone conduction loss in the presence of a good ear on the opposite side), a radical mastoidectomy may be done During the period of this report, we performed radical mastoidectomy for chronic suppuration on two ears in which preoperative tests revealed profound sensory-neural type deafness

TYPES OF TYMPANOPLASTY

Tympanoplasty has a dual objective: the first is elimination of disease, and the second is reconstruction of the sound transmitting system. Reconstruction is attempted only after

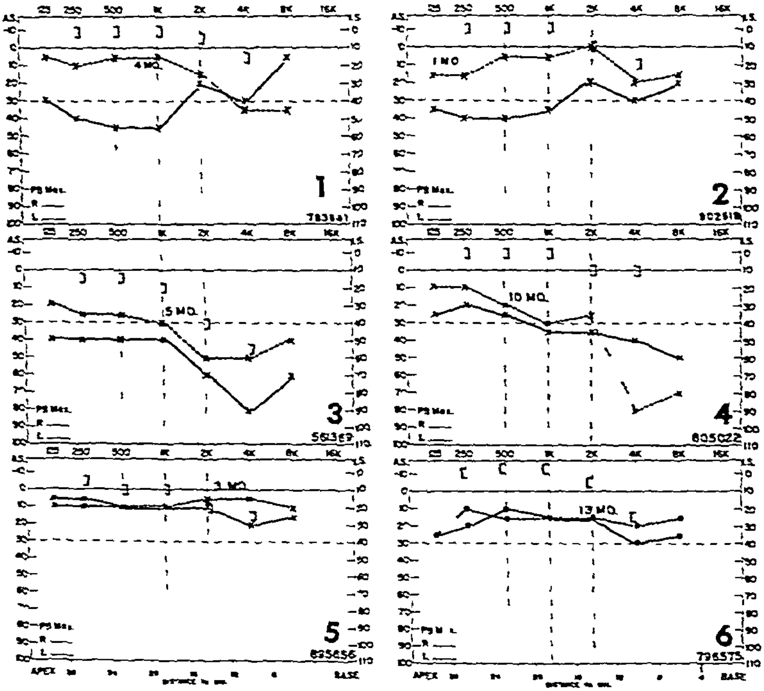
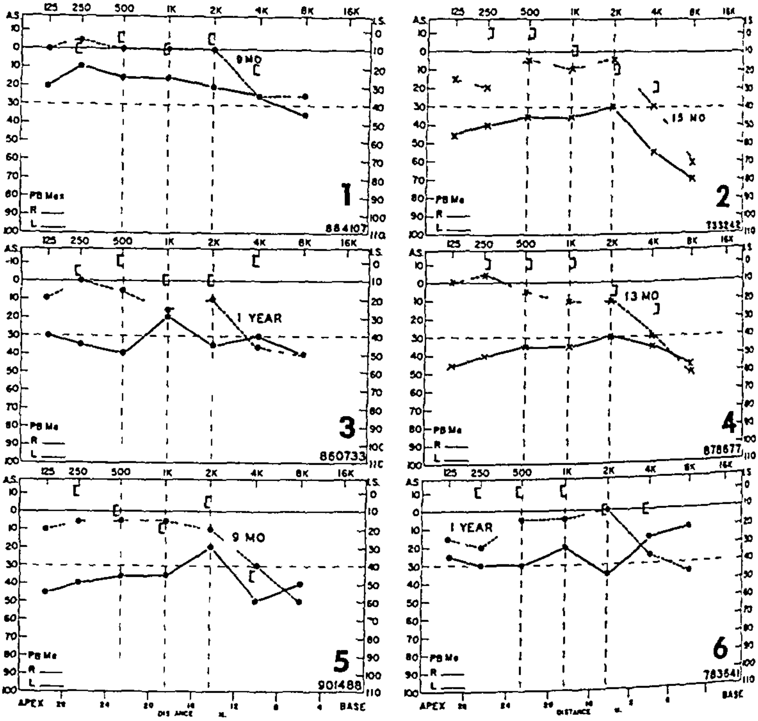


Fig 3 Examples of successful Type II-A tympanoplasties. Cases 2, 3, 4 and 5 without mastoidectomies.

the underlying disease has been completely irradicated. The surgical methods which will eliminate disease while preserving middle ear mucosa and the conducting mechanism are technically difficult and the end results are largely dependent upon the skill and experience of the surgeon.

The theory of tympanoplasty has been discussed in detail



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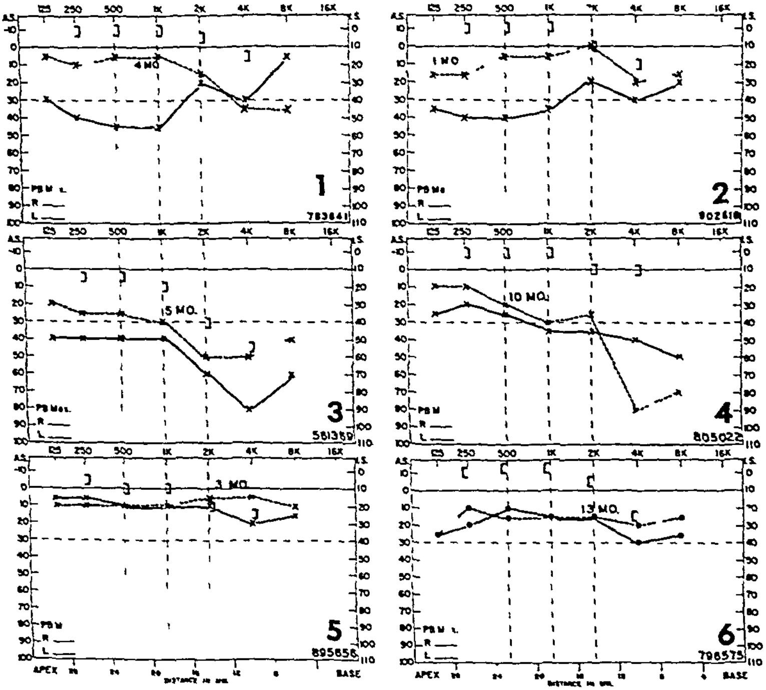

Fig 3 Examples of successful Type II-A tympanoplasties Cases 2 3 4 and 5 without mastoidectomies

The theory of tympanoplasty has been discussed in detail elsewhere[4] In brief, the objective is to create a sound pressure differential between the oval and round windows (with or without the sound conducting mechanism)

The meticulous classification of tympanoplasty operations permits one to predict the patient's chances for improved hearing and allows the surgeon to compare his results with

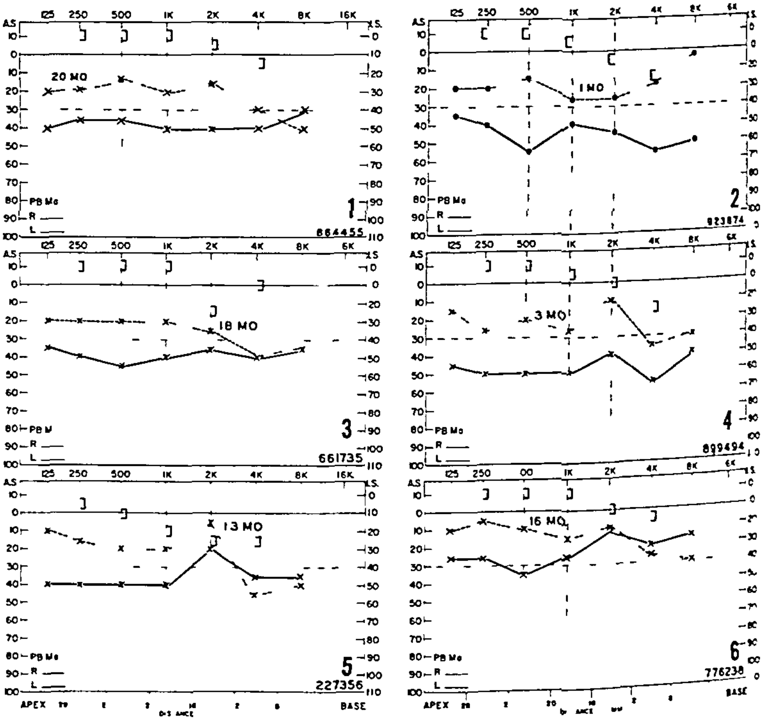

Fig 4 Examples of successful Type III-A tympanoplasties Case 2 without mastoidectomy

those of others We have followed Zollner's modification of the classical Wullstein classification (see Table I)

Type I Plastic Repair of Drum with or without Meatoantrotomy

This operation consists of the plastic repair of a perforation of the tympanic membrane and it may include reflecting the ear drum forward and removing some of the posterior bony annulus so as to inspect the ossicles, windows, sinus tympani and antrum The existing pars tensa and annulus fibrosus are preserved and denuded of epithelium along with the adjacent canal wall (if necessary) to provide an adequate bed for the graft We almost always use the post-auricular approach to the tympanic space After elevating a meatal skin flap, the external auditory canal is widened with a burr (except in those patients having large canals or those with small easily visible perforations) The full-thickness skin graft[*]

TABLE I

Types (Zollner)
I—Plastic repair of drum with or without meato antrotomy
II A—Attico antrotomy with plastic repair of drum
II B—Simple attico antrotomy
III-A and IV-A—Total plastic repair (malleus and incus destroyed) Large graft
III-B and IV-B—Minor plastic repair (malleus and incus destroyed), half or more of drum remaining Graft used as necessary to complete closure
V—Plastic operation and subsequent fenestration

(III—placed on stapes) (IV—placed on promontory)

bridges the tympanic space and extends onto the posterior canal wall as necessary to cover bone exposed as a result of enlarging the ear canal We occasionally permit large grafts to lie on a small de-epithelialized area on the promontory to assure nourishment of the central part of the graft

Type II-A Attico-antrotomy with Plastic Repair of Drum

Plastic repair of the tympanic membrane is accomplished with or without meato-antrotomy plus exposure and exenteration of disease in the attic The skin graft may extend onto the head of the malleus and body of the incus, bridging to the canal wall or into the mastoid cavity if a mastoid exenteration is done If the operation is done without a mastoidectomy, it is essential that a mucosal-lined tract extend from the anterior tympanic region through the superior aspect of the attic to the mastoid so as to allow aeration of the mastoid cells It is often important to determine the condition of the mastoid antrum by either a limited meato-antrotomy or a superior observation window The observation window is made in the posterior-superior canal wall and allows inspection of the mastoid antrum and posterior part of the epitympanic space

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[*] In reality these grafts although removed as full-thickness are thinned with scissors to the junction of the papillary and reticular layers of the derma.

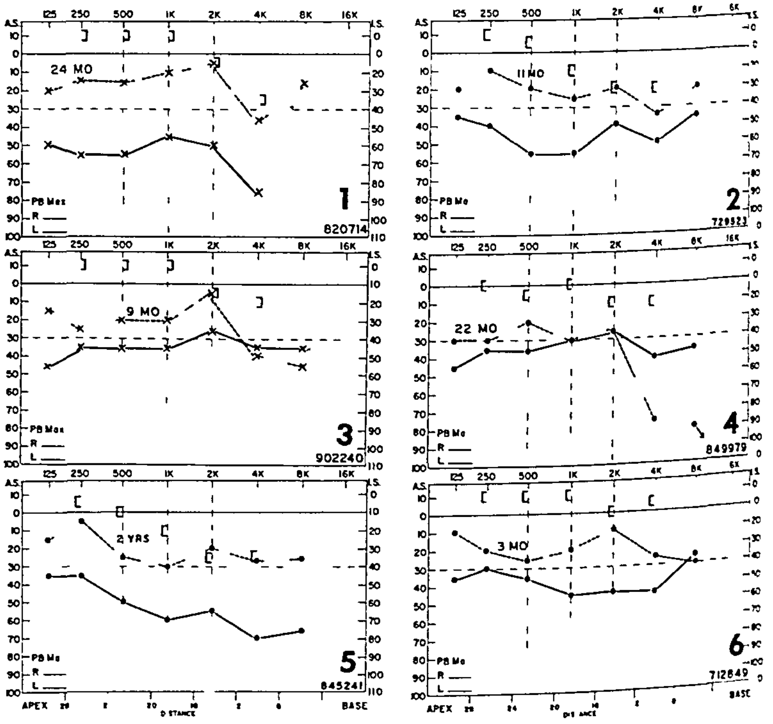

Fig 5 Examples of successful Type IV tympanoplasties Case 2 without mastoidectomy

and is covered by the skin graft Even though a mastoidectomy is necessary, it is desirable to preserve bony annulus when possible, for this "bridge" minimizes cicatricial immobilization of the incus, especially if the mucosa is preserved in this area Included in Group II-A are patients in whom the incus or malleus or both have been transposed between the graft and the stapes creating thereby a "columnella" effect

Type II-B Simple Attico-antrotomy

This operation is a well-known type of modified radical mastoidectomy The pars tensa and ossicular chain are intact, and the operation is directed at meticulous removal of disease from the attic region The mastoid may be exenterated and if so, an attempt is made to preserve the "bridge" In such cases, the skin graft passes from the upper part of the tympanic membrane to the "bridge," thereby closing the attic perforation and extends into the mastoid cavity Again, if the mastoid is not diseased, it is not necessary to perform a mastoidectomy as long as a mucosal-lined tract extends from the anterior tympanic region through the epitympanum to the mastoid air cell system to assure aeration of the mastoid

Types III-A and IV-A Total Plastic Repair (drum malleus and incus destroyed), Large Graft

Wullstein has classified those operations in which the ear drum or graft is placed upon the head of the stapes as Type III and those in which the oval window is exteriorized and the graft or tympanic membrane is laid upon the promontory as Type IV This classification takes into account the physiological differences occurring when sound is transmitted to the head of the stapes through a membrane and that occurring when sound strikes the footplate directly

Zollner has subclassified these types into the "total plastic" (Type III-A and IV-A) and the "minor plastic" (Type III-B and IV-B) In the total plastic, there is complete loss of the tympanic membrane requiring that the graft bridge the gap from the annulus to either the stapes (Type III-A) or promontory (Type IV-A) In the minor plastic there is preservation of half or more of the ear drum and the graft is used if necessary to complete the closure, either to the stapes (Type III-B) or to the promontory (Type IV-B) We utilize Zollner's subclassification because it seems that a good result depends more upon the condition of the mucosa and the size of the graft than it does upon whether or not the reconstruction utilizes the "columnella effect" of the stapes

Diseased tissue is removed meticulously from the tympanic space using great care not to damage the mucosa These operations can be performed with or without mastoidectomy The graft lays on the de-epithelialized antero-inferior canal wall and bridges the tympanic space to the promontory or head of the stapes, whichever is appropriate

Types III-B and IV-B Minor Plastic Repair (malleus and incus destroyed), Remaining Drum Used with Small Graft

When half or more of the tympanic membrane remains, there is often healthy mucosa in the hypotympanum The success rate is much higher than in the total plastic regardless of whether the graft or tympanic membrane attaches to the head of the stapes or to the promontory If the existing tympanic membrane is inadequate in itself then a graft is used to complete the closure, again, the operation may be done with or without a mastoidectomy A radical mastoid cavity should not be created unless necessary, for to do so creates a post-operative surgical state which occasionally requires interval care for many years In our series of 119 patients of Types II, III and IV, mastoidectomy was avoided in 26 (22 per cent) (See Table II)

TABLE II

MASTOIDECTOMY

Type	Total Number	With Mastoid	Without Mastoid
II-A and II-B	17	6	11
III A and IV A	82	71	11
III-B and IV B	20	16	4
Total	119	93 (78%)	26 (22%)

In all Type III operations, it is essential that the facial ridge be de-epithelialized, for the membrane (drum or graft) must contact this region to maintain its position on the head of the stapes In Type IV tympanoplasty, it is not known whether it is best to preserve the mucosa on the footplate or remove it, and if the mucosa is removed, whether the footplate should be left denuded or covered with a graft We have employed all these methods with success

Type V Plastic Operation and Subsequent Fenestration

This procedure applies only to ears with fixation of the stapedial footplate and must be done in two stages The first objective is to create both a mastoid cavity and a sealed-off hypotympanic (and possibly mesotympanic) space encompassing the round window The adequacy of this tympanic space should be established with certainty by controlled inflation and simultaneous inspection of the graft under magnification before the second stage (fenestration operation) is performed

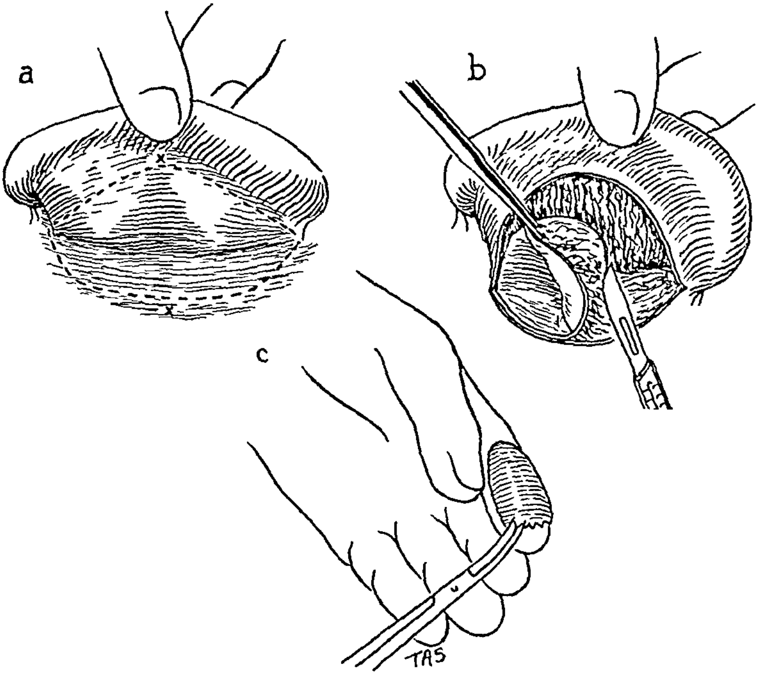

Fig 6 a —Incisions for removal of post-auricular skin b —The skin is removed with a sharp knife cutting through the underlying fatty subepithelial layers c —The skin is thinned with a sharp curved scissors, either on the finger or on a block When the skin graft is to lie on the antero-inferior canal wall folding of the graft can be minimized by serrating this margin

FURTHER COMMENTS ON TECHNIQUE

The post-auricular skin contains little elastic tissue and,

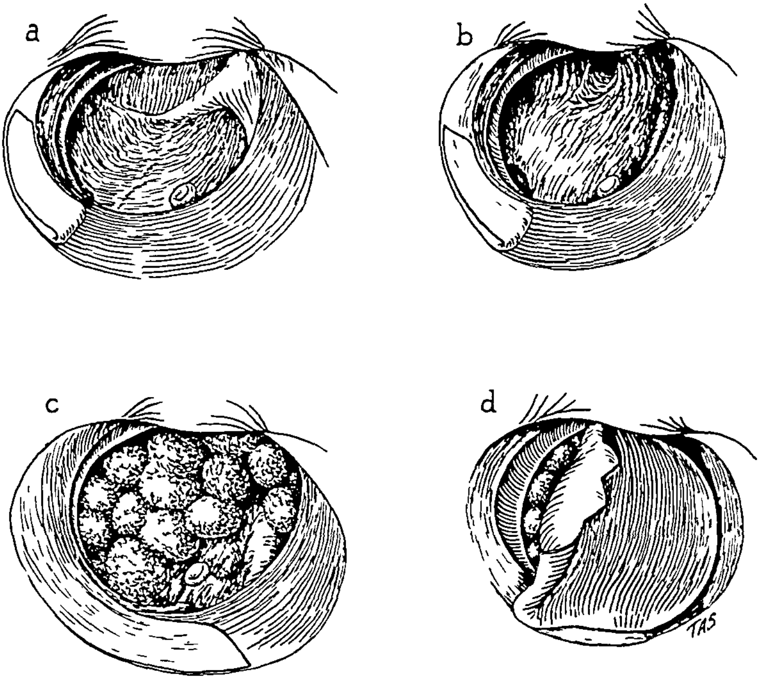

Fig 7 Technique for Type III-A tympanoplasty without mastoidectomy a—The tympanic membrane and the incus are missing The malleus is present and the handle is adherent to the promontory The external auditory canal has been enlarged and the skin of the posterior canal has been reflected inferiorly b—The malleus has been removed and the attic and antrum have been inspected and found to contain healthy mucosa c—The antero-inferior canal wall has been de-epithelialized the facial ridge has been denuded and the tympanic space and attic filled with small pieces of gelfoam The meatal flap has been replaced against the posterior canal wall d—The full-thickness skin graft is placed so as to lie on the antero-inferior canal wall and extend across the tympanic space to the head of the stapes and facial ridge and back to the posterior canal wall The graft is fitted onto the posterior canal wall so as to cover any bare bone

therefore, when used as a full-thickness graft, it is easier to manipulate and maintain in position than split thickness skin Our post-auricular grafts vary in size from 2 to 3 cm in width to 4 to 6 cm in length We remove the skin at the beginning of the operation and keep it in heparinized refrigerated blood until time for introduction It is then thinned with a small curved scissors and trimmed to proper size The tympanic space is filled with pieces of gelfoam to aid in supporting the graft The question as to whether gelfoam stimulates connective tissue proliferation has not been completely answered Grafts which extend upon the antero-inferior canal wall are serrated at its margin to facilitate introduction without the formation of folds (see Fig 6-c) The graft is meticulously approximated to its bed, trimming as necessary to avoid folds Small cotton balls soaked in Ringer's solution are used to hold the graft tightly into its bed, particularly in the acute angle at the annulus antero-inferiorly An attempt is made to stretch the graft across the tympanic cavity under some tension When the graft is to cover the footplate, it is invaginated into the oval window with a small cotton ball The entire cavity is lined with rayon strips, after which larger

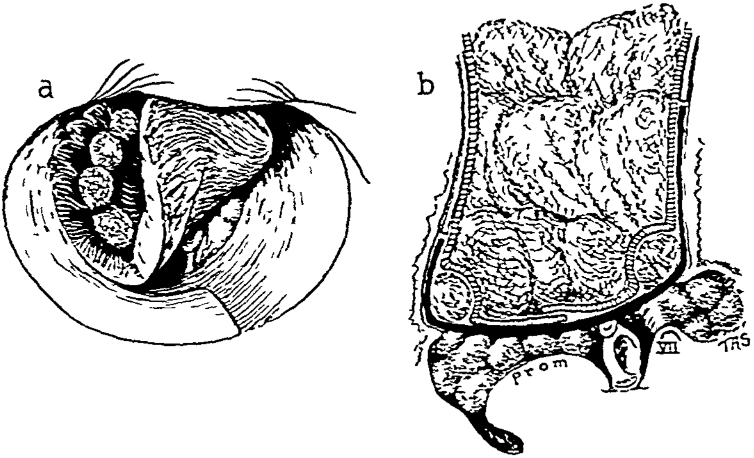

Fig 8 Packing the graft into place a.—Cotton balls soaked in Ringer's solution are used to hold the graft against the canal wall at the annulus as necessary b—Rayon strips are used to cover the entire cavity so as to create a complete sleeve Larger cotton balls soaked in Ringer's solution are introduced into the bottom of the sleeve and packed firmly against the canal walls Further packing consists of synthetic sponge rubber and vaseline gauze

cotton balls are appropriately placed so as to create firm pressure against the graft This is followed by pieces of synthetic rubber and finally vaseline gauze packing (see Figs 6, 7, 8) Perre[6] stresses the importance of accurate approximation and firm pressure and we are inclined to agree with him Split thickness grafts were taken from the chest, thigh or inner surface of the arm in 14 of our series of 160 tympanoplasties In most of these patients, full-thickness skin was not available because of post-auricular scars These grafts were cut 015 inches (38 mm) thick and although the skin was more difficult to handle, the results were as good

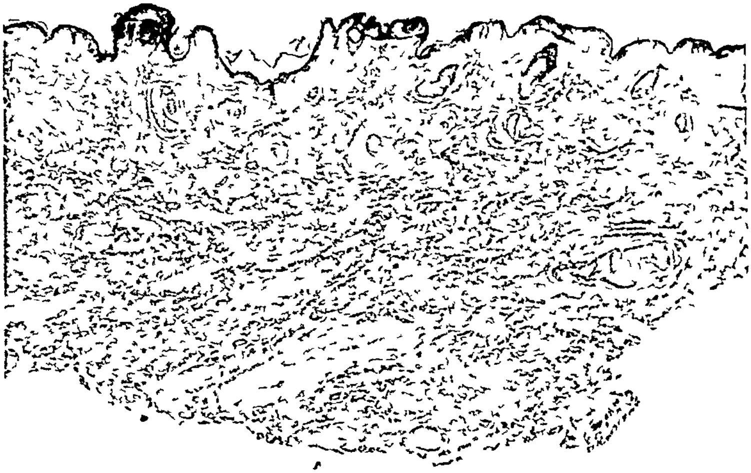

Fig 9-a Photomicrograph of full-thickness post-auricular skin removed at the time of surgery showing sebaceous glands and a rather thick layer of sub-epithelial fatty tissue

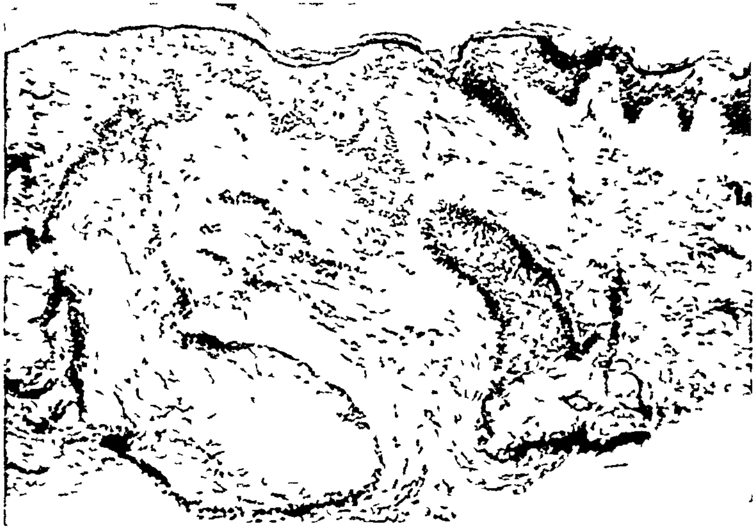

Fig 9-b Appearance of graft after thinning Note the presence of sebaceous glands The dermis contains blood vessels of the subpapillary network the importance of which has been emphasized by Guilford and Wright[10]

as with full thickness grafts Photomicrographs of full-thickness and split thickness grafts are shown in Figs 9 and 10 Fig 11 shows a full thickness graft removed six months after surgery because of a perforation The tympanic surface is lined by a transitional epithelium

Surgical rayon is placed upon the donor site of split-thickness grafts and covered with a gauze dressing The following day, the dressing including the surgical rayon is removed and

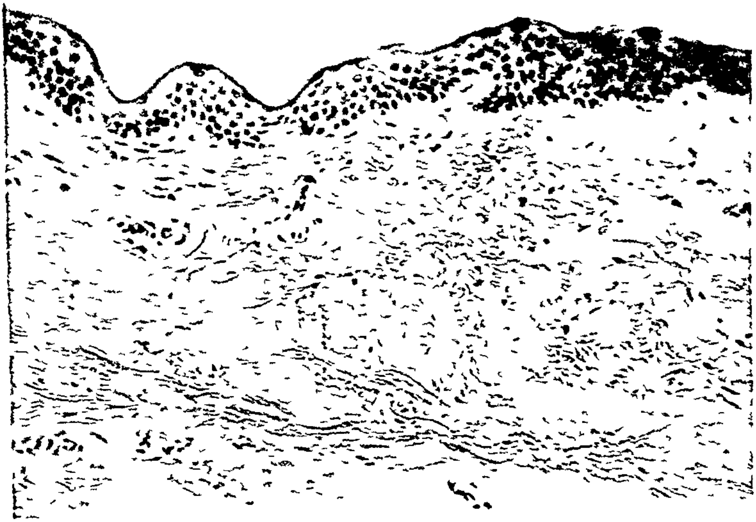

Fig 10 Photomicrograph of split thickness skin from the anterior chest wall cut at a thickness of 015 inches Note the absence of glands It should be understood that the grafts appear considerably thicker in these views than they are when cut because of fibrous tissue shrinking and because of the thickening which occurs from fixation

the donor site is exposed to the drying effect of a heat lamp for two hours morning and afternoon Drying of the donor site permits rapid healing without crusting or adherent dressings

The packing is removed from the ear on the seventh postoperative day, and the middle ear is inflated by the Valsalva technique using not more than 60 mm of mercury pressure (see Fig 1).

FINDINGS AT OPERATION

Labyrinthine fistulas were present in six of the 160 ears In five ears, the fistulas were located in the horizontal semicircular canal and in one, there were three fistulas in the cochlear wall

Tympanosclerosis was present in five ears in our series, and in four of these was located in the submucosal layers of the tympanic cavity involving the promontory, sinus tympani, oval window and stapes, facial ridge and epitympanum In one chronically discharging ear, there was a large ball of the material lying free in the tympanic space In each case, it was removed with care to avoid unnecessary damage to mucosa and a satisfactory hearing status was acquired in three of the five patients

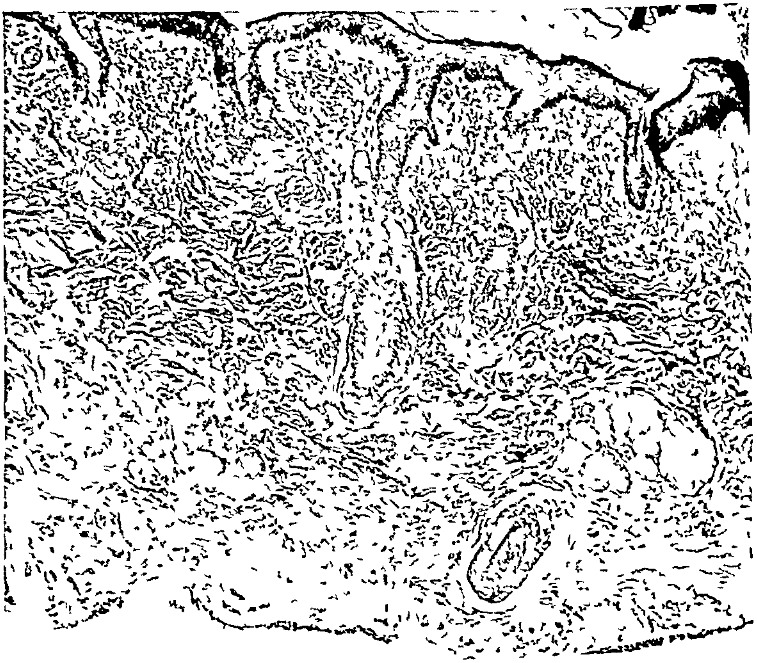

Fig 11-a Photomicrograph of full-thickness skin graft removed after six months because of a perforation On the external surface there is a normal layer of squamous cell epithelium whereas the tympanic surface is lined with a transitional cell epithelium There are active sebaceous glands throughout the graft substance

In this condition, the mucosa of the middle ear loses its soft pinkish moist appearance and is replaced by a nodular grayish yellow or whitish hard mass The ear may be dry with no active discharge, although there is always a history of previous long standing ear infection The lesion usually involves part or all of the medial wall of the middle ear and may cover the promontory, round window, hypotympanum, sinus tympani and reach into the epitympanum All of the ossicles may be

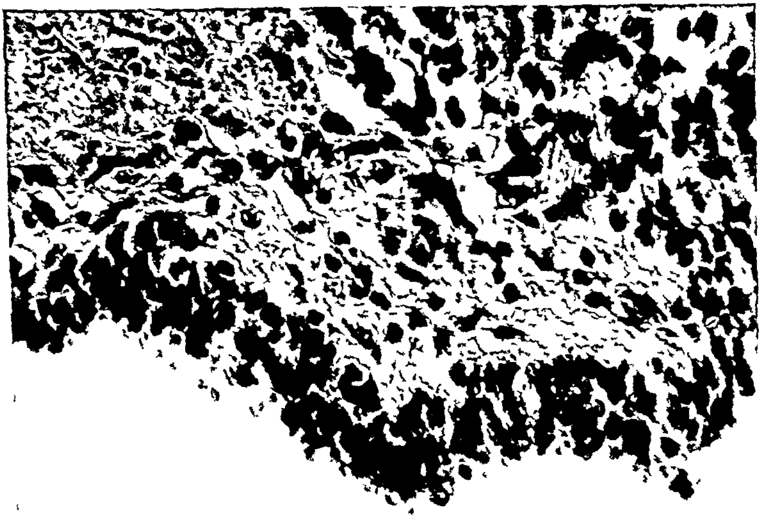

Fig 11-b High power view of transitional cell epithelium lining the tympanic surface of the graft

bound down in this mass Tympanosclerosis may not be detected preoperatively if only a small perforation is present Zollner states that tympanosclerotic material is located in the deep layer of the submucosa and is not in direct contact with the bone of the osseous labyrinth or with the ossicles

The microscopic picture is that of diffuse hyalinization of collagenous fibers with a few scattered plasma cells and lymphocytes There is a minimal deposit of minute calcium particles on the surface of the material (see Fig 13)

FINDINGS AT OPERATION

Labyrinthine fistulas were present in six of the 160 ears. In five ears, the fistulas were located in the horizontal semicircular canal and in one, there were three fistulas in the cochlear wall.

Tympanosclerosis was present in five ears in our series, and in four of these was located in the submucosal layers of the tympanic cavity involving the promontory, sinus tympani, oval window and stapes, facial ridge and epitympanum. In one chronically discharging ear, there was a large ball of the material lying free in the tympanic space. In each case, it was removed with care to avoid unnecessary damage to mucosa and a satisfactory hearing status was acquired in three of the five patients.

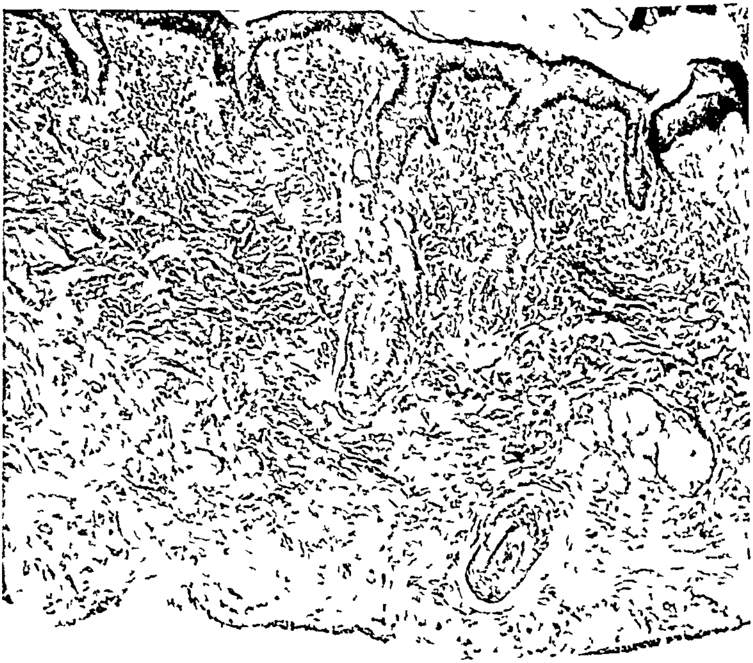

Fig. 11-a. Photomicrograph of full-thickness skin graft removed after six months because of a perforation. On the external surface there is a normal layer of squamous cell epithelium whereas the tympanic surface is lined with a transitional cell epithelium. There are active sebaceous glands throughout the graft substance.

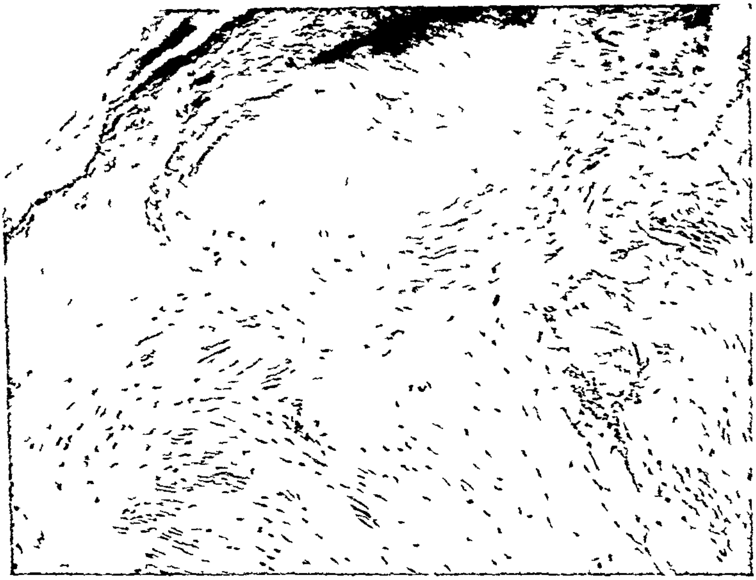

Fig 13-a Photomicrograph showing tympanosclerotic material removed from the promontory at the time of surgery It consists of dense hyalinized collagenous connective tissue with minimal cellular infiltrate of plasma cells and lymphocytes

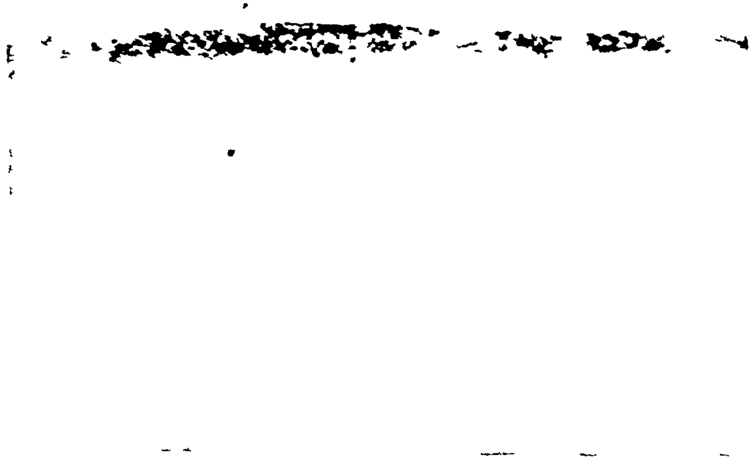

Fig 13-b VonKossa stain showing calcium deposit at the surface of the tympanosclerotic mass

Fixation of the stapes with otosclerotic bone was found in four patients—two in whom the diagnosis was made preoperatively Stapes mobilization was performed at the time of the tympanoplasty, but in none was there significant postoperative hearing gain One of these was subsequently fenestrated to become a successful Type V tympanoplasty (see Fig 14)

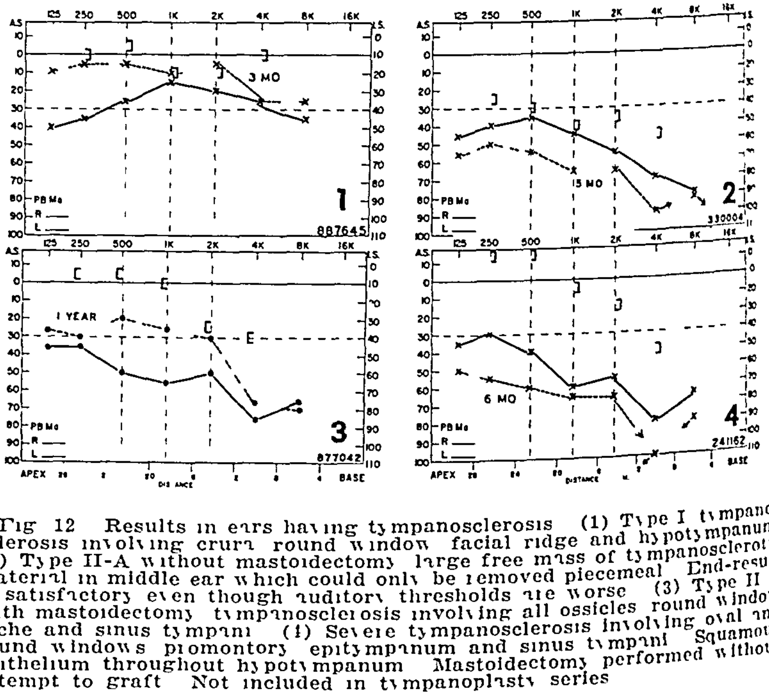

Fig 12 Results in ears having tympanosclerosis (1) Type I tympanosclerosis involving crura round window facial ridge and hypotympanum (2) Type II-A without mastoidectomy large free mass of tympanosclerotic material in middle ear which could only be removed piecemeal End-result is satisfactory even though auditory thresholds are worse (3) Type II A with mastoidectomy tympanosclerosis involving all ossicles round window niche and sinus tympani (4) Severe tympanosclerosis involving oval and round windows promontory epitympanum and sinus tympani Squamous epithelium throughout hypotympanum Mastoidectomy performed without attempt to graft Not included in tympanoplasty series

Type III tympanoplasty was often necessary when there was necrosis of the long process of the incus (see Fig 15)

In four ears with limited disease, it was possible to transpose the malleus and incus so as to establish a "columnella effect" Excellent results were acquired in three of the patients—a fourth failing because of a graft necrosis (see Fig 16)

On seven patients, the surgery was performed when there existed a profound deafness in the opposite ear In two of the operated ears, there had been a progressive drop in bone conduction thresholds during the months immediately preceding surgery In operating these patients, great care was used to avoid opening the labyrinth For this reason, we believe that mucosa or squamous epithelium located in either the oval or round windows usually should not be disturbed in these cases In none of these seven patients was the hearing made worse and in four there were significant hearing gains (see Fig 17)

It is well-known that auditory thresholds can be maintained at a functionally satisfactory level by cholesteatoma, granulations, tympanosclerosis, pus and false membranes The correction of these diseased states can lead to slightly worse hearing even though technically successful reconstructive surgery has been accomplished In assessing the results of tympanoplasty, it is of importance to understand that in some cases the failure to improve hearing or even a slight aggravation of the hearing loss may constitute an excellent functional result It is in reality, the final status of the bone-air gap which is the significant criterion of success For example, some patients already have "Type IV" hearing because of a false membrane which has created an air pocket encompassing the round window During the period of this report, we encountered four ears with functioning false membranes They were preserved in two and replaced by graft in two with good results in all If a false membrane is creating "Type IV"

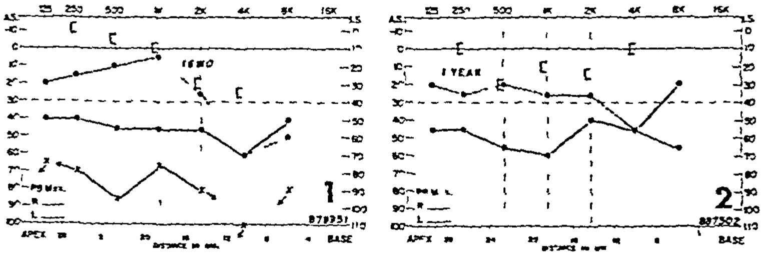

Fig 16 Ossicular transpositions were performed in four ears with excellent results in all Two audiograms are shown In Case 1 an atticoantrotomy because of incudal necrosis was performed without mastoidectomy The malleus was transposed so that the neck was interposed between the head of the stapes and the full-thickness graft Case 2 had a severe auditory deficit in the opposite ear These cases were classified as Type II-A tympanoplasties

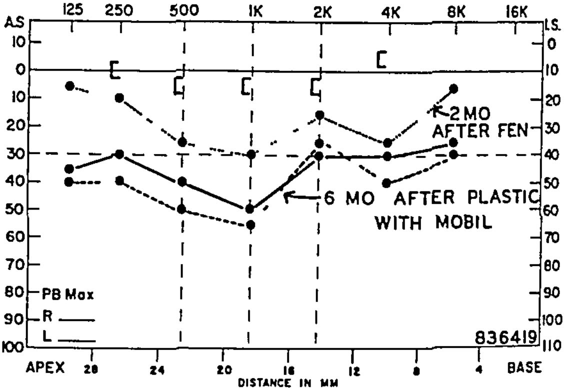

Fig 14 Audiogram of our only Type V tympanoplasty

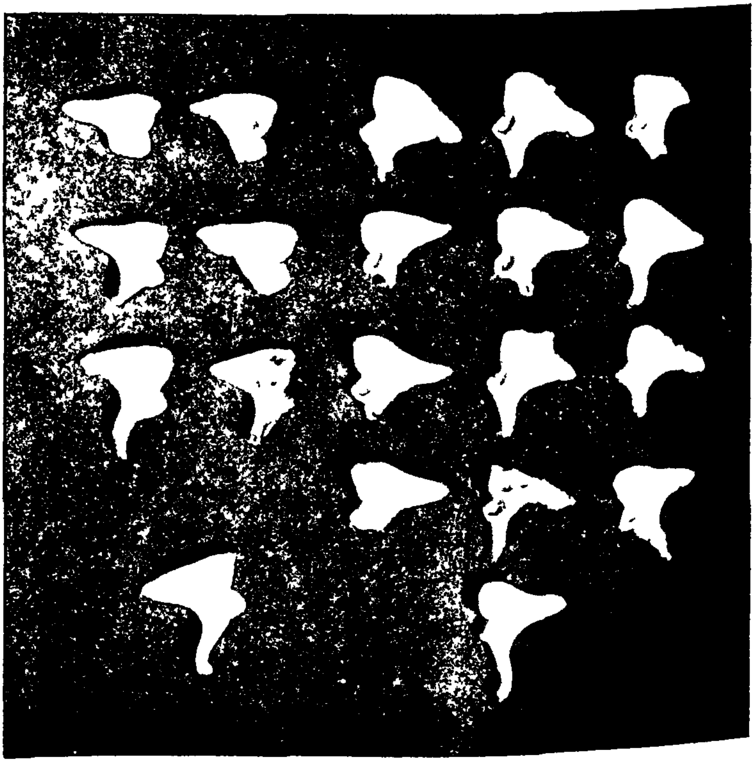

Fig 15 Incuses removed on Type III tympanoplasty cases showing the common pathological findings of necrosis of its long process Normal right and left incuses shown below

administered either with the above equipment or, using the regularly calibrated speech audiomter, in a two-room testing unit, using monitored live voice techniques *

Preoperative and postoperative hearing levels were determined by averaging the three speech frequencies of 500, 1,000 and 2,000 cps All preoperative and postoperative tests were performed after inflation and careful cleaning of the ear canal, mastoid and tympanic areas

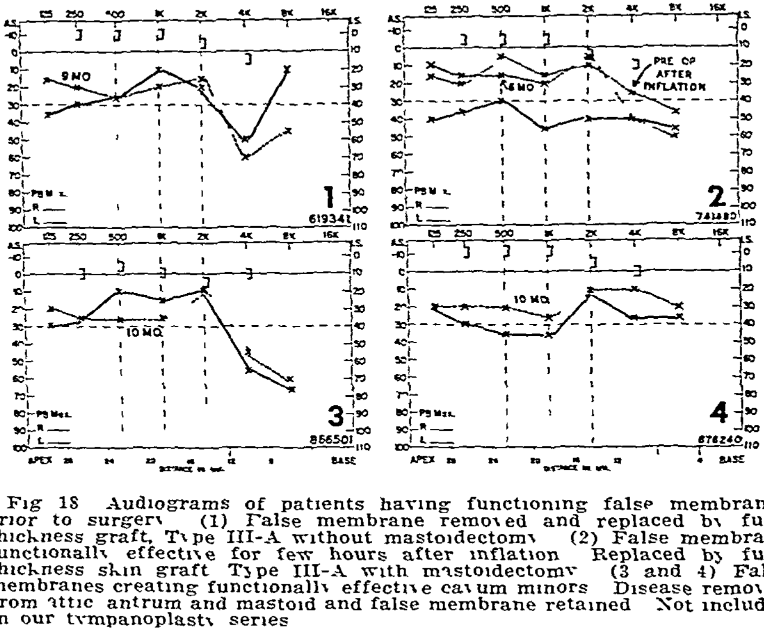

Fig 18 Audiograms of patients having functioning false membranes prior to surgery (1) False membrane removed and replaced by full-thickness graft, Type III-A without mastoidectomy (2) False membrane functionally effective for few hours after inflation Replaced by full-thickness skin graft Type III-A with mastoidectomy (3 and 4) False membranes creating functionally effective cavum minors Disease removed from attic antrum and mastoid and false membrane retained Not included in our tympanoplasty series

We are aware that the Otosclerosis Study Group recently recommended that corrective middle ear surgery be evaluated on the basis of percentage of closure of the bone-air gap We have analyzed all of our results in this way but find the data difficult to interpret The reason for this is that for tympanoplasty operations *1* the ideal result (except for Type I cases) is less than complete closure of the bone-air gap, and

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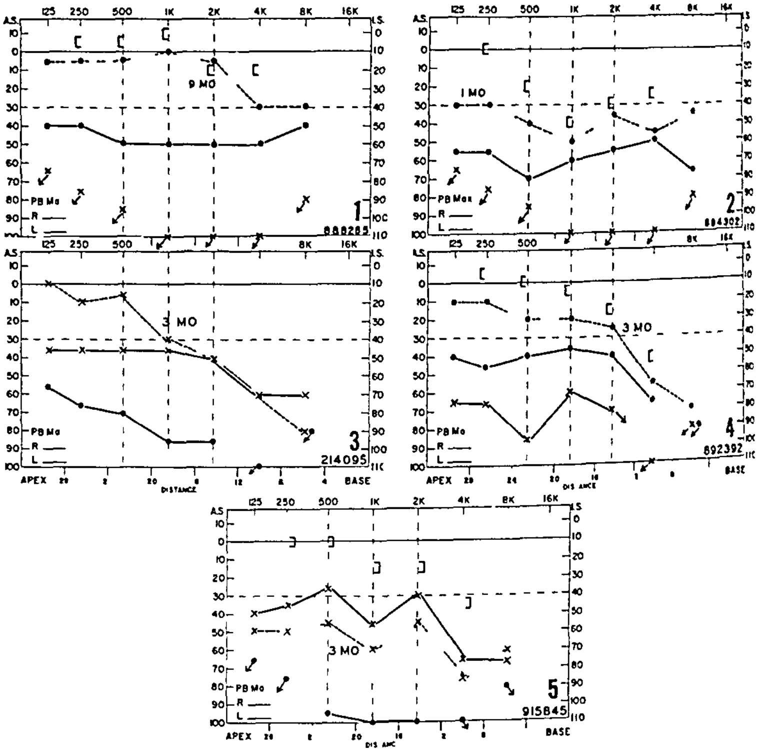

Fig 17 Audiograms of patients having tympanoplasties in the presence of severe auditory deficits in the opposite ear (1) III-B with mastoidectomy (2) III-A with mastoidectomy (3) III-A with mastoidectomy (4) II-A without mastoidectomy

hearing and it can be replaced by a graft so as to convert it to a "Type III" hearing, this probably should be done (see Fig 18) We did not include in our tympanoplasty series those two ears in which false membranes were left in place

RESULTS

Our experience consists of 160 tympanoplasties performed during a two-year period (see Table III) The audiograms were performed in *acoustically-treated* rooms with an ambient noise level of less than 50 db in the critical frequency bands with commercially available clinical audiometers The calibration of each audiometer was standardized regularly with the Allison calibration unit, Model 3A Speech tests were administered either with the above equipment or, using the regularly calibrated speech audiomter, in a two-room testing unit, using monitored live voice techniques*

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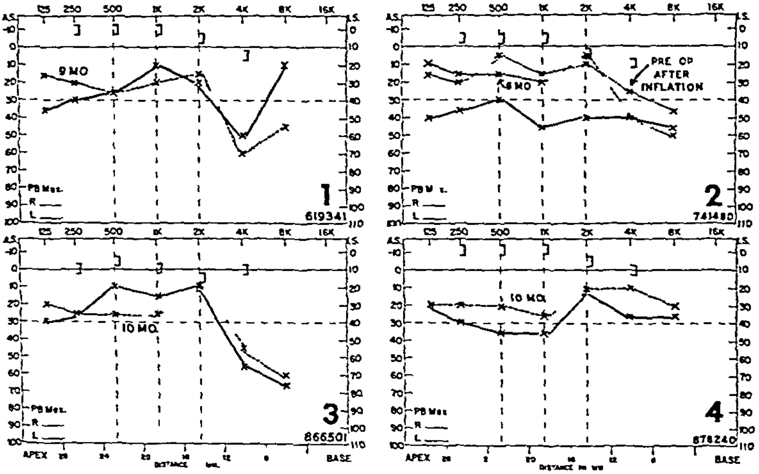

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2 a successful result need not give a hearing gain and may even result in a slight hearing loss For each type of tympanoplasty, we have determined the number of cases which acquired an absolute level of 30 db, 20 db and 5 db (absolute meaning actual audiometer readings) and the number acquiring a bone-air gap of 30 db or less All statistical analyses are based on the American Standard Audiometric Zero (see Table III)

TABLE III —RESULTS

	No Cases	Acquired 30 db Level (absolute)		Acquired 20 db Level (absolute)		Acquired 5 db Level (absolute)		Bone-air Gap 30 db or Less		Made Worse 5 db or More
	40	33	(82%)	25 50% to 15 db	(62%)	5	(12%)	34	(85%)	4
	15	10	(67%)	7	(47%)	2		12	(80%)	3
	2	2		1		0		2		0
A, IV A	82	39	(48%)	13	(16%)	0		50	(61%)	8
B, IV B	20	14	(70%)	9	(45%)	0		16	(80%)	1
	1	1		1		0		1		0
	160	99	(62%)	56	(35%)	7		115	(72%)	16 (10%)

TABLE IV

Case Classification, Based on Bone Conduction (Shambaugh)
Average for 500 1,000 2,000 cps

Class	Definition	Tympanoplasty Types I	II	III	IV	V	Totals
A	15 db or less	39	14	41	56	1	= 151
B	16 to 25 db	1	1	1	0	0	= 3
C	26 to 35 db	1	1	2	1	0	= 5
D	36 db or more	0	0	0	1	0	= 1
Total		41	16	44	58	1	160

If we utilize the Shambaugh definition of case classifications, we find that nine (6 per cent) of 160 patients had bone conduction averages for 500, 1,000 and 2,000 cps of 15 db or more (see Table IV)

As expected, the best results were for the 40 Type I cases, where 82 per cent acquired a 30 db level and the poorest for the 82 "total plastic" cases (III-A and IV-A), where only 48 per cent acquired a 30 db level Of the 20 "minor plastic" cases, 70 per cent acquired a 30 db level indicating an improved prognosis when at least half of the eardrum remains A comparison of our results with those of Zollner is shown in Table V

A comparison of our results with European authors is valid, *of course, only if our audiometers are calibrated to the same* Audiometric Zero as theirs We do not know at this time to what standard the German audiometers are calibrated

Of the total group of 160 cases, there were 16 (10 per cent) which were made worse by 5 db or more Several of these were worse by less than 15 db and maintained a threshold level better than 30 db

TABLE V

Type	Criteria	Zollner (278)	Schuknecht et al (160)
I	Bone-air gap 30 db or less	94% (of 52)	85% (of 40)
	Acquired 15 db level or better	62%	50%
	Acquired 5 db level or better	19%	12%
II-A	Bone-air gap 30 db or less	56% (of 39)	80% (of 15)
	Acquired 20 db level or better	27%	47%
III A IV-A	Bone air gap 30 db or less	56% *(of 133)*	61% (of 82)
	Acquired 20 db level or better	23%	16%
III-B IV B	Bone-air gap of 30 db or less	72%	80%
	Acquired 20 db level or better	42%	45%

It should be pointed out that it is sometimes difficult to determine in what type classification a particular case should be placed For example, if the stapes is present and one-half the tympanic membrane, more or less is usable for reconstruction, should the case be classified as Type III-A or Type III-B? If one author places that case in Type III-A and another in Type III-B, the comparison of these authors' results has little significance Table VI contains a comparison of our results with those of Wullstein[8] and Proctor[9]

POSTOPERATIVE FINDINGS

One of the causes for failure is excessive scarring of the graft to the medial tympanic wall When this results in an inadequate tympanic space so that the round window is not in an air containing pocket, there is no hearing gain and there may be a hearing loss, depending upon the preoperative levels (see Fig 19) This unfortunate result is usually caused by epithelial denudation of the hypotympanum whether it be unavoidable, inadvertent or accidental, therefore, it is of great importance to avoid the excessive removal of mucosal polyps and granulations from the hypotympanum, medial tympanic wall and round window niche It may be preferable in some cases to allow the inflammatory reaction of the mucosa to subside and introduce the graft at a second operation It is the opinion of some otologists, however, that multiple operations create excessive scarring The question as to how to handle these difficult cases has not yet been answered In our series, there were 20 tympanoplasty failures because of "scarred-down" grafts

TABLE VI

Results

Type	Acquired 30 db level		Schuknecht et al
	Wullstein (250)	Proctor (66)	(119)
II	73% (of 74)	70% (of 23)	80% (of 17)
III	80% (of 133)	58% (of 26 cases)	66% (of 44 cases)
IV	75% (of 43)	69% (of 17 cases)	42% (of 58 cases)

Another cause of failure is necrosis of the graft in the area of the tympanic cavity This occurred in 14 ears and predominantly in our early cases (see Fig 20)

Small (occult) perforations existed in 15 ears These perforations were not visible to the naked eye, however, when controlled air pressure was delivered during the Valsalva maneuver, air was heard to squeak through a small perforation or the graft was seen to flutter at a small point They

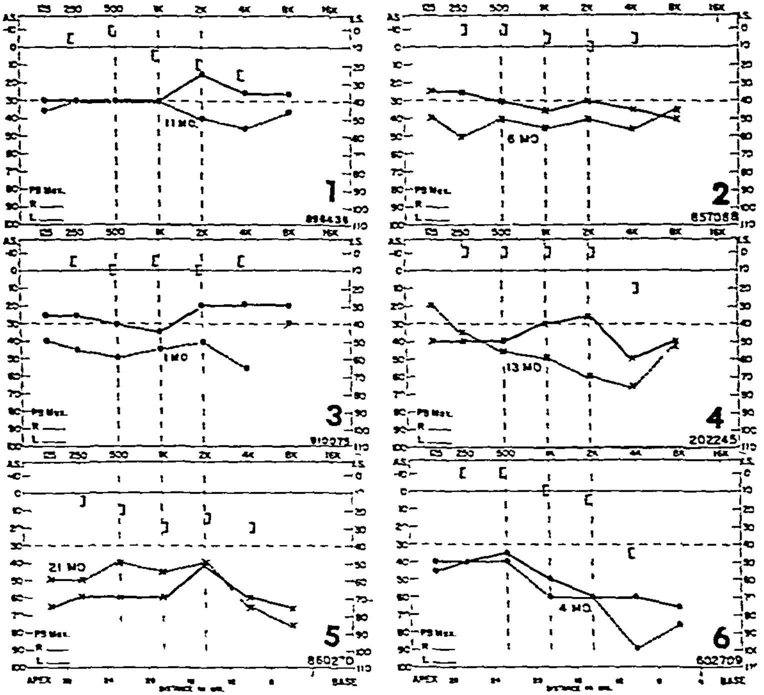

Fig 19 Failures due to scarred-down grafts (1) Graft adherent to round window niche Type III-A. (2) Graft adherent to round window niche because of removal of granulations in that area, Type IV-A. (3) Adhesions of graft to hypotympanum Type IV-A. (4) Graft adherent to round window niche Type IV-A. (5) Extensive scarring of graft to hypotympanum Type IV-A. All of these ears suffered advanced soft tissue changes in the mesotympanic and hypotympanic areas

do not appear to affect the hearing result Only time will tell whether these small perforations will result in deterioration of the present satisfactory postoperative state There was recurrence of middle ear cholesteatoma in three patients, all of whom have been recently reoperated

There was postoperative fluctuation of hearing in three patients This appeared to result from relaxed grafts which were made to bulge away from the round window niche on inflation but after a few seconds or minutes returned to their original position thereby eliminating again the sound pressure differential To avoid this complication, the operative technique should be directed at providing adequate depth to the

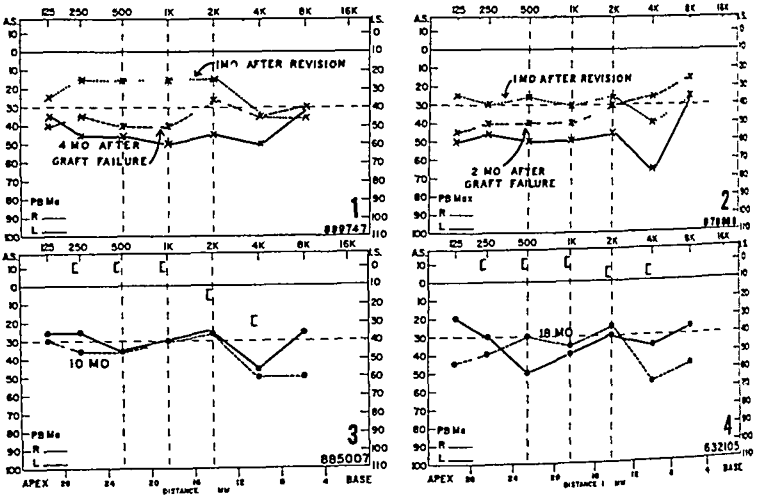

Fig 20 Examples of failure because of partial graft necrosis (1) Type III-A with mastoidectomy, subsequent successful reoperation (2) Type III-A with mastoidectomy, subsequent successful reoperation (3) Type I recently reoperated successfully (4) Type IV-A with mastoidectomy to be reoperated Cause for graft necrosis appear to be multiple (1) Improper fitting and approximation of graft to its bed (2) Inadequate packing (3) Failure to remove underlying disease (4) Failure to prepare a properly de-epithelialized bed (5) Infection At reoperation the old graft must be completely removed and replaced

TABLE VII

Postoperative Findings (160 Cases)	
Scarred down graft	20
Partial necrosis of graft	14
Minute (occult) perforations	15
Recurrence of cholesteatoma	3
Fluctuating hearing	3
Continued suppuration	4

cavum minor Thus, the annulus should be preserved inferiorly and the graft stretched across the tympanic space

Of 136 patients with a follow-up period of three months or longer, four continued to have discharging mastoid cavities (see Table VII)

Bone conduction losses were experienced in four ears (see Fig 21) In one, the loss may have been due to a small perforation in the footplate occurring when tympanosclerotic material was removed from the oval window In the others, the reason for the bone conduction losses remain unexplained In two, the losses were progressive over a period of months following surgery They were not associated with vestibular symptoms and, therefore, are probably not due to diffuse serous labyrinthitis One might speculate that the operation in some way has promoted the absorption of toxic material through the round window membrane which has damaged the sense organ

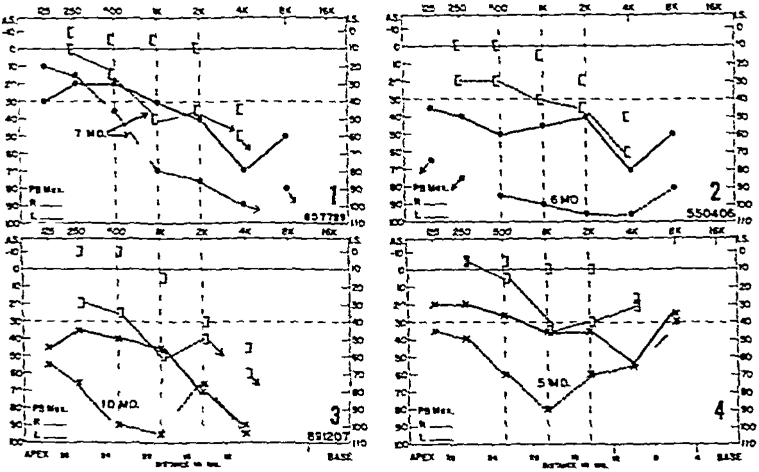

Fig 21 Sensory-neural losses following tympanoplasty (1) Type I with successful grafting The loss for bone conduction thresholds was slowly progressive over a seven-month period (2) Type III-A with mastoidectomy In this case the bone conduction loss plus a scarred down graft has resulted in a severe hearing loss (3) Type IV-A with mastoidectomy (4) Type IV-A with mastoidectomy There was advanced tympanosclerosis of the promontory sinus tympani facial ridge and filling of the oval window The ossicles except for the footplate were missing A small perforation was made inadvertently in the footplate as otosclerotic material was removed in this region and may be the cause for the bone conduction loss in this case

CONCLUSIONS

Tympanoplasty surgery is an exercise in micro-surgical technique which requires good judgment, great patience and an understanding of the physiological principles of sound transmission

Success depends upon meticulous removal of diseased tissues and reconstruction of the tympanic space so as to accomplish a columnella effect and/or a pressure differential at the windows

It is most important that the mucosa of the tympanum, medial tympanic wall and round window area be cautiously preserved and that the skin graft, preferably full-thickness from the post-auricular sulcus, be trimmed, fitted and packed into place with great care

Ten per cent of the patients were made worse by 5 db or more, but several of these losses were less than 15 db and have been corrected subsequently by surgical revision The percentage of good cases increases with time as our surgical technical ability has improved The two main reasons for tympanoplasty failure are *1* partial graft necrosis, and *2* scarring of the graft into the hypotympanum Four of the patients have had a significant unexplained loss of bone conduction thresholds

An analysis of the results of 160 tympanoplasties reveals that a 30 db level was acquired by 82 per cent of Type I cases, 70 per cent of Type II cases, 48 per cent of total plastic cases (Type III-A and IV-A) and 70 per cent of minor plastic cases (Type III-B and IV-B)

Our experience has shown that damage to ossicles and tympanic membranes was less in the younger age group and the success of tympanoplasty operations depends in part upon early intervention in chronic irreversible suppurative middle ear disease

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bones should not be rare, but, strangely enough, no true proven case has been reported to my knowledge One would expect this to be one of the most common congenital anomalies found in the human body

4 A disturbance in formation of the incudostapedial joint may involve other structures, such as the stapedius muscle and the head of the malleus An example of this is a patient, whom I have previously presented,[13] with triple bony union of the malleus, incus and stapes and absence of the stapedius muscle, tendon and pyramidal eminence (see Fig 5)

II Incudostapedial Joint Separation Due to Surgical Procedures

Today, this is perhaps the most common cause of interruption of the ossicular chain Separation of this joint has occurred in innumerable cases as the result of surgical maneuvers during the operation for mobilization of the stapes Fortunately, repositioning at the time of surgery can many times be accomplished, but often the lenticular process has been irreparably damaged and a true incudostapedial joint separation results (see Figs 6 and 6-a)

Other surgical procedures about the mastoid and middle ear may also cause dislocation One authority reported one case[27] and another authority[31] recently reported three cases, in which there was a dislodgement of the incus from its epitympanic and stapedial attachments during a previous simple mastoidectomy

III Incudostapedial Joint Separation Due to Inflammatory Necrosis of the Long Process of the Incus

This is a very commonly observed pathologic cause of incudostapedial joint separation (see Fig 8) The long process of the incus is more vulnerable to damage from inflammation than any other portion of the ossicular chain[13] The major reason for this is the fact that the long process of the incus projects for a considerable distance into an air-containing cavity and is a longer distance away from soft tissue blood supply than any other portion of the ossicular chain Thus, an acute inflammatory process of the middle ear may be con-

INCUDOSTAPEDIAL JOINT SEPARATION ETIOLOGY, TREATMENT AND SIGNIFICANCE*

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Oklahoma City, Okla

ETIOLOGY OF INCUDOSTAPEDIAL JOINT SEPARATION

I Incudostapedial Joint Separation from Congenital Causes

1 The malleus and incus are derived from the first visceral arch (see Fig 1) Improper differentiation of this arch may cause distortion or absence of the incus When other anomalies are not present, a total absence of the incus is considered to be quite rare I have found only one case of total absence of the incus thought to be of congenital etiology (see Fig 2)[1]

2 Improper differentiation of only the long process of the incus can produce the functional effect of incudostapedial joint separation[13] Fig 3 is a photograph presenting this condition as found in a ten-year-old child with conductive deafness, which I considered to be congenital Tympanotomy revealed a distorted thick stapes with congenital fixation of the footplate The incus was nothing more than a band of heavy connective tissue without bony content

3 Embryologically, the incus is derived, as previously stated, from the first visceral arch whereas the stapes is derived from the second visceral arch (see Fig 4) Contact of the lenticular process of the incus with the head of the stapes and consequent formation of the incudostapedial joint occurs in the eighth week of fetal life The attraction of these two bony surfaces for each other is phenomenal and unparalleled in the human body It is amazing that they so uniformly come together and join in an articulation The congenital abnormality of lack of articulation of these two

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*Read at the meeting of the Eastern Section of the American Laryngological Rhinological and Otological Society Inc New York N Y Jan 8 1959

†From Department of Otolaryngology Oklahoma City Clinic Wesley Hospital Foundation

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4 A disturbance in formation of the incudostapedial joint may involve other structures, such as the stapedius muscle and the head of the malleus An example of this is a patient, whom I have previously presented,[13] with triple bony union of the malleus, incus and stapes and absence of the stapedius muscle, tendon and pyramidal eminence (see Fig 5)

II *Incudostapedial Joint Separation Due to Surgical Procedures*

Today, this is perhaps the most common cause of interruption of the ossicular chain. Separation of this joint has occurred in innumerable cases as the result of surgical maneuvers during the operation for mobilization of the stapes Fortunately, repositioning at the time of surgery can many times be accomplished, but often the lenticular process has been irreparably damaged and a true incudostapedial joint separation results (see Figs 6 and 6-a)

Other surgical procedures about the mastoid and middle ear may also cause dislocation One authority reported one case[27] and another authority[31] recently reported three cases, in which there was a dislodgement of the incus from its epitympanic and stapedial attachments during a previous simple mastoidectomy

III *Incudostapedial Joint Separation Due to Inflammatory Necrosis of the Long Process of the Incus*

This is a very commonly observed pathologic cause of incudostapedial joint separation (see Fig 8) The long process of the incus is more vulnerable to damage from inflammation than any other portion of the ossicular chain[13] The major reason for this is the fact that the long process of the incus projects for a considerable distance into an air-containing cavity and is a longer distance away from soft tissue blood supply than any other portion of the ossicular chain Thus, an acute inflammatory process of the middle ear may be con-

INCUDOSTAPEDIAL JOINT SEPARATION: ETIOLOGY, TREATMENT AND SIGNIFICANCE.*

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ETIOLOGY OF INCUDOSTAPEDIAL JOINT SEPARATION

I. *Incudostapedial Joint Separation from Congenital Causes.*

1. The malleus and incus are derived from the first visceral arch (see Fig. 1). Improper differentiation of this arch may cause distortion or absence of the incus. When other anomalies are not present, a total absence of the incus is considered to be quite rare. I have found only one case of total absence of the incus thought to be of congenital etiology (see Fig. 2).[1]

2. Improper differentiation of only the long process of the incus can produce the functional effect of incudostapedial joint separation.[13] Fig. 3 is a photograph presenting this condition as found in a ten-year-old child with conductive deafness, which I considered to be congenital. Tympanotomy revealed a distorted thick stapes with congenital fixation of the footplate. The incus was nothing more than a band of heavy connective tissue without bony content.

3. Embryologically, the incus is derived, as previously stated, from the first visceral arch whereas the stapes is derived from the second visceral arch (see Fig. 4). Contact of the lenticular process of the incus with the head of the stapes and consequent formation of the incudostapedial joint occurs in the eighth week of fetal life. The attraction of these two bony surfaces for each other is phenomenal and unparalleled in the human body. It is amazing that they so uniformly come together and join in an articulation. The congenital abnormality of lack of articulation of these two

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One authority recently reported one case of incudostapedial joint separation apparently due to a non-fracturing blow on the head[31] Another authority recently reported a case of bilateral incudostapedial joint separation due to severe head injury[9] Several other cases of conductive deafness, probably due to ossicular chain separation from trauma to the head, have been reported to me by personal communication[8, 29] A few of these have been proven, others are awaiting exploratory tympanotomy I now have two cases awaiting operation which might well fall into this group

I am sure that this cause of deafness is not as rare as is suggested by the lack of evidence in the literature On the contrary, the fact that I have seen this many cases suggests that injury is not an uncommon cause of incudostapedial joint separation

Several factors will make this condition more frequently observed in the future

1 More tympanic cavities will be explored when unexplained conductive deafness is found in either one or both ears

2 In this age more head injuries will occur from high speed vehicles and industrial accidents

3 More severely injured patients will be kept alive by modern surgical and medical measures

4 By realizing that a conductive deafness may result from this cause, otologists will doubtless find and correct this disability in more patients in the future

DISCUSSION OF TRAUMA TO THE HEAD IN RELATION TO INCUDOSTAPEDIAL JOINT SEPARATION

Immediately, our thinking is arrested by the query as to what might possibly have happened to cause separation of this joint during these traumatic moments when the injury to the head is occurring

1 An important factor to be considered in incudostapedial joint separation due to injury of the head is the effect of trolled after it has caused necrotic destruction of the long process of the incus The remainder of the middle ear, as well as the tympanic membrane, may return to a normal state In such a case, the loss of function will be almost entirely due to interruption of the ossicular chain, and the hearing will be at a near 60 db threshold If a tympanotomy is done, a normal tympanic membrane will be encountered, and when elevated the structures of the middle ear may be curiously free of any evidence of previous disease with the one exception of destruction from necrosis of the long process of the incus

IV *Incudostapedial Joint Separation Due to Head Injury*

Much exceptionally fine investigative work has been directed toward the effects of injury on the ear [2,3,17] Detailed analyses of the effects of concussion and skull fracture have been brilliantly presented by many contributors [10,11 12 18 19 20 24 2 39] From an audiologic standpoint, the chief finding in these cases reported was that of perceptive loss from cochlear damage We now know that the conductive loss of hearing in head injury is quite common[13] (see Audiogram I)

On February 7, 1957, I did a tympanotomy on a patient with the anticipation of doing a mobilization of the stapes [13] This patient had a 67 db pure tone loss in the speech frequencies with a near normal bone conduction On entering the middle ear, the stapes was found to be quite mobile, but there was a total incudostapedial joint separation (see Fig 9) This patient had given a history of having suffered a severe blow on his head during his youth and had stated that he believed the onset of his hearing loss to be at that time Head injury, producing marked cochlear damage, could easily be explained by information reported by previous investigators, but ossicular disarticulation had been very rare even in crushing head injuries producing death I reported this case, but, although the history was strongly suggestive, I held at that time some reservation in stating that trauma was definitely the etiologic factor Since that time I have encountered two more cases of unilateral conductive deafness due to incudostapedial joint separation produced by skull fracture In these cases, there was little doubt as to the history about 1 gm tension under experimental conditions[39, 40] This would represent a substantial force in the human Another investigator found that the human stapes could be pulled back for a distance of 200 micra by a simple acoustic reflex[40] The anterior portion of the annular ligament was pulled back and stretched 60 micra The inward motion of the footplate of the stapes was measured in a rabbit by one authority to be 0 027 mm on acoustic stimulation[40]

Although the stapedius muscle is extremely small, if it were thrown into sudden severe tetanic contraction by severe injury (trauma to the head), the total force would be exerted against the smallest joint in the human body Even large bones are occasionally fractured in this way during shock therapy

The pull of the tensor tympani producing a firm medial thrust of the incus with a simultaneous exceptional posterior pull on the head of the stapes from the stapedius muscle action might be a factor in producing disarticulation of the joint

Another factor may be the twisting of the incudostapedial joint Some authorities consider the ear to have two axes of rotation[23] One axis is along a line through the short process of the incus and the anterior ligaments of the malleus, the other, from the head of the stapes to the footplate

Incudomallealar articulation divides the two large ossicles into two portions of equal weight[23] Along this axis is a line where the moment of inertia of the ossicles is at its lowest value The weights above and below are equal The upper mass acts as a counter-weight on the lower mass

Utilizing certain laws of physics, it can be demonstrated that the incudostapedial joint acts much like the well-known "universal joint" because it lies between the two major axes of rotation As the "universal joint" in a machine prevents a disastrous play of unbalanced counter-forces from producing destruction or distortion during the transmission of energy, likewise the incudostapedial joint performs this vital role in sound transmission

This "universal joint" concept is related to the incudo-stapedial joint separation in the following way If a low concussion A severe vibratory reaction to an impact sufficient to produce fracture of the skull may cause momentary separation and weakening of the tissues with loss of elasticity The cohesiveness of the tissues is temporarily disrupted as though there had been an explosion among the cells

2 Still another factor is the law of physics related to inertia Newton's law of motion related to inertia states that "A body at rest will remain at rest and a body in motion will continue in motion with constant speed in a straight line, as long as no unbalanced force acts upon it"[28]

When the head is in motion and strikes a stationary object, all of the head tends to continue in motion (see Fig 23) The moveable objects within the head, *e g*, brain, ossicles, etc, must react in a physical way to acceleration and deceleration Even when the head is stopped, the brain, ossicles, etc, must be under a strong force to remain in motion in accordance with the laws of inertia In an opposite way, the same is true when the head is struck by a moving object This factor in incudostapedial joint separation is mentioned here for completeness of thought, but consideration of these facts is not considered desirable in this publication

3 The action of the tympanic muscles must be considered

The two tympanic muscles are partially counter-active in the force they exert on the ossicular chain This permits delicate regulation of its rigidity in suspension

The structural arrangement of the muscular fibers are of a pennate type which allow some fibers within the muscle to either release or neutralize others This partially explains why the tensions produced by these muscles are less proportionately than would be expected from their size Nevertheless, the linear force exerted by the stapedius muscle is considerable

Investigators have attempted to determine the maximum tension of which these muscles are capable One investigator estimated that the tensor tympani in a rabbit exerted approximately 1 2 gm pull when stimulated by sound[22] Other investigators estimated that the stapedius muscle of a cat exerted about 1 gm. tension under experimental conditions.[39, 40] This would represent a substantial force in the human. Another investigator found that the human stapes could be pulled back for a distance of 200 micra by a simple acoustic reflex.[40] The anterior portion of the annular ligament was pulled back and stretched 60 micra. The inward motion of the footplate of the stapes was measured in a rabbit by one authority to be 0.027 mm. on acoustic stimulation.[40]

Although the stapedius muscle is extremely small, if it were thrown into sudden severe tetanic contraction by severe injury (trauma to the head), the total force would be exerted against the smallest joint in the human body. Even large bones are occasionally fractured in this way during shock therapy.

The pull of the tensor tympani producing a firm medial thrust of the incus with a simultaneous exceptional posterior pull on the head of the stapes from the stapedius muscle action might be a factor in producing disarticulation of the joint.

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Incudomallealar articulation divides the two large ossicles into two portions of equal weight.[23] Along this axis is a line where the moment of inertia of the ossicles is at its lowest value. The weights above and below are equal. The upper mass acts as a counter-weight on the lower mass.

Utilizing certain laws of physics, it can be demonstrated that the incudostapedial joint acts much like the well-known "universal joint" because it lies between the two major axes of rotation. As the "universal joint" in a machine prevents a disastrous play of unbalanced counter-forces from producing destruction or distortion during the transmission of energy, likewise the incudostapedial joint performs this vital role in sound transmission.

This "universal joint" concept is related to the incudostapedial joint separation in the following way. If a low frequency tone (10 cycle) is administered to the normal ear in increasing intensity, the perceived loudness will increase as expected, however, at a certain critical point, contrary to *expectation, further increase of intensity will result not in* increase in loudness, but in decrease This indicates that a protective mechanism has come into action It has been thought that the entire mode of action of the ossicles changes at this time The stapes stops rotating about the vertical axis, which produces an ever increasing pressure against the cochlea Instead, the stapes turns in a rotary action at right angles to the previous axis This is thought to cause the labyrinthine fluid to flow from one edge of the footplate of the stapes to the other in an ineffective manner, thus protecting the cochlea from trauma

Thus, we can see the importance of this incudostapedial "universal joint" in allowing the structure of the middle ear to vibrate in two different modes with ability to transfer from one mode to the other when a sudden need arises This ability may, however, add to the vulnerability of the incudostapedial joint to separation A sudden severe vibration may cause this twisting shearing motion, and in combination with the other forces of trauma to the head may cause the joint to become separated

In summarizing, these may be some of the factors producing incudostapedial joint separation in trauma to the head

1 The presence of tissue weakness due to the explosive effect of concussion

2 The simultaneous jarring effect, tending to produce derangement of all moveable parts according to the laws of physics related to inertia

3 A sudden severe tetanic contraction of the tympanic muscles with an abrupt change in the axis of rotation of the ossicles

TREATMENT OF INCUDOSTAPEDIAL JOINT SEPARATION

Several methods of restoration of hearing following incudostapedial joint separation need to be considered

I STAPEDIOPEXY.

This is the surgical procedure used in most of the cases of incudostapedial joint separation which have been previously reported in the literature [27, 31, 33] Stapediopexy must remain as the cornerstone for restoration of the transmission of sound from the tympanic membrane to the cochlea when this joint is separated; nevertheless, there are several disadvantages

Disadvantages of Stapediopexy

1 Stapediopexy is frequently a major operative procedure and results in considerable morbidity

2. Stapediopexy frequently requires an endaural incision with removal of enough of the posterior superior bony canal wall to allow a tympanomeatal flap to be brought down into contact with the head of the stapes If removal of a considerable amount of bone in this area is needed, a cavity is created which may lose its ability to cleanse itself and thus require continuous observation

3. In stapediopexy, it may be necessary to cut the chorda tympani nerve in order to bring the tympanomeatal flap medially against the head of the stapes

4 The handle of the malleus is located near the center of the tympanic membrane, and is designed to collect the energy of sound without loss of efficiency If the head of the stapes is to receive this energy directly, one must consider the fact that it is not located in the most efficient area of the tympanic membrane, furthermore, unless the handle of the malleus is dissected from the drum and removed, it will act as a buffer and tend to dampen and dissipate sound This loss is admittedly small, but even 2 to 3 db is worth infinite care in preserving when the end-result may be near the critical 30 db level

5 In stapediopexy, there is no assurance that the head of the stapes will adhere to the mucous membrane lining of the tympanic membrane I have found it mechanically quite difficult to denude the inner surface of the tympanic membrane in the desired area This single objection, however, can easily be overcome by a simple procedure which I now frequently employ in cases which require stapediopexy.

Procedure to Insure Union of the Stapes Head to the Tympanic Membrane.

1 Mobilize the tympanomeatal flap so that it will come into contact with the head of the stapes (see Fig. 17). This may require a wide exposure and the removal of a considerable amount of bone of the posterior superior canal wall. In some patients, a narrow field exposure may be all that is necessary. A simple shifting of the tympanic membrane in the posterior superior quadrant, medially to the head of the stapes, may be accomplished. The depth of the middle ear will be the determining factor.

2 Locate the point of contact of the tympanic membrane with the head of the stapes. At this point make a small incision through the eardrum with a knife or pick (see Fig. 18). Roughen the head of the stapes with a pick.

3 Insert the head of the stapes into the newly made hole in the tympanic membrane (see Fig. 19) and place a small piece of gelfoam over it (see Fig. 20). Follow this by a routine dressing to the external canal.

This procedure insures a fibrous union of the tympanic membrane with the head of the stapes in exactly the desired location.

The above procedure is used only in cases of an intact eardrum.

Those cases which require skin graft, of course, need not have this operation to insure adherence.

In spite of the above disadvantages, stapediopexy is one of the most successful methods for restoration of hearing in cases of incudostapedial joint separation.[15,16] At the present time, stapediopexy occupies a position of usefulness in those cases where it is impossible to use the incus or malleus in the reconstruction of the conductive bridge.[7]

II REPOSITIONING OF THE LENTICULAR PROCESS OF THE INCUS ON THE HEAD OF THE STAPES

The second procedure for the repair of incudostapedial joint separation is the repositioning of the lenticular process of the incus on the head of the stapes Due to the number of operations for mobilization of the stapes being done, this is undoubtedly the most frequently performed procedure for repair of incudostapedial joint separation and is the simplest Figs 12 and 13 are photographs of a patient with a fracture of the skull Please note the skull fracture in the posterior superior canal wall Repositioning is the procedure of choice in those cases of mechanical separation of the incudostapedial joint in which natural apposition is easily attained Fortunately, healing of this joint by union with soft tissue is usually dependable[2 4] Repositioning was possible here with a good result (see Fig 14, Audiogram III) The type of joint thus established in the process of repair is unknown,[2] but study of this with experimental animals is now beginning

III THE USE OF AUTOGENOUS BONE GRAFT FOR THE REPAIR OF INCUDOSTAPEDIAL JOINT SEPARATION

The third procedure which may be used to repair an incudostapedial joint separation is the use of an autogenous graft of bone The use of a small bone graft between the widely separated joint surfaces of the incus and stapes was previously reported by the author[13] (see Figs 9, 10, 11, Audiogram II) This method has been employed on numerous occasions before and since, and has been uniformly and apparently permanently successful I recommend it as an amazingly simple and effective procedure in the treatment of this condition

Technique

1 Make a routine mobilization of the stapes incision and expose the middle ear in the incudostapedial joint area It is easy to continue the incision if a wide endaural approach for stapediopexy is found to be needed (see Fig 17).

2 Roughen with a pick the joint surface of the lenticular process of the incus and the articulating surface of the head of the stapes (see Fig 9)

3 Remove a curette full of bone from the posterior superior canal wall to be used as a bone graft (see Fig 21) An attempt is made to take a piece of bone approximately twice as large as the area needed to be grafted

4 With picks, tease the small bone graft between the articulating surfaces of the incus and stapes to fill the area of separation (see Figs 7, 11, 16) Hearing is usually restored instantaneously (see Audiograms II, IV, V)

Fig 9 is a photograph of a patient with a head injury Audiogram I demonstrates the hearing level prior to joint restoration Fig 11 is a photograph of the bone graft in place Audiogram II represents the restoration of hearing in this patient two years after reconstruction Fig 15 is that of a photograph of joint separation from fracture of the skull Fig 15-a is a supermagnification of this separation The photograph in Fig 16 demonstrates repair by graft of bone from the posterior superior canal wall Results of this repair are shown on the audiogram one year later (Audiogram IV) Fig 6 is a photograph of a patient one year after stapes mobilization It is noted that there has been necrosis of the lenticular process of the incus with separation of the incus from the stapes Fig 6-a is a super-magnification of this separation The photograph in Fig 7 demonstrates a repair by graft of bone from the posterior superior canal wall Hearing was restored to a good serviceable level following this reconstructive surgery (see Audiogram V)

DISCUSSION OF THE USE OF BONE GRAFTS IN THE MIDDLE EAR

If bone grafts will produce a functional result when inserted into an air-containing cavity and situated at a point relatively remote from an abundant blood supply, it is the author's opinion that autogenous bone grafts can be used in many ways to repair conductive lesions of the middle ear.

One may ask, what are the end-results of healing with bone grafts of this type? It is unknown whether or not this bone remains viable as bone It may change into thick fibrous tissue In either case, it is apparent that it is efficient in restoring this joint to a peak of maximum conductive ef-

INCUDOSTAPEDIAL JOINT SEPARATION

J V D Hough

PRESENTATION OF PHOTOGRAPHS AND DRAWINGS

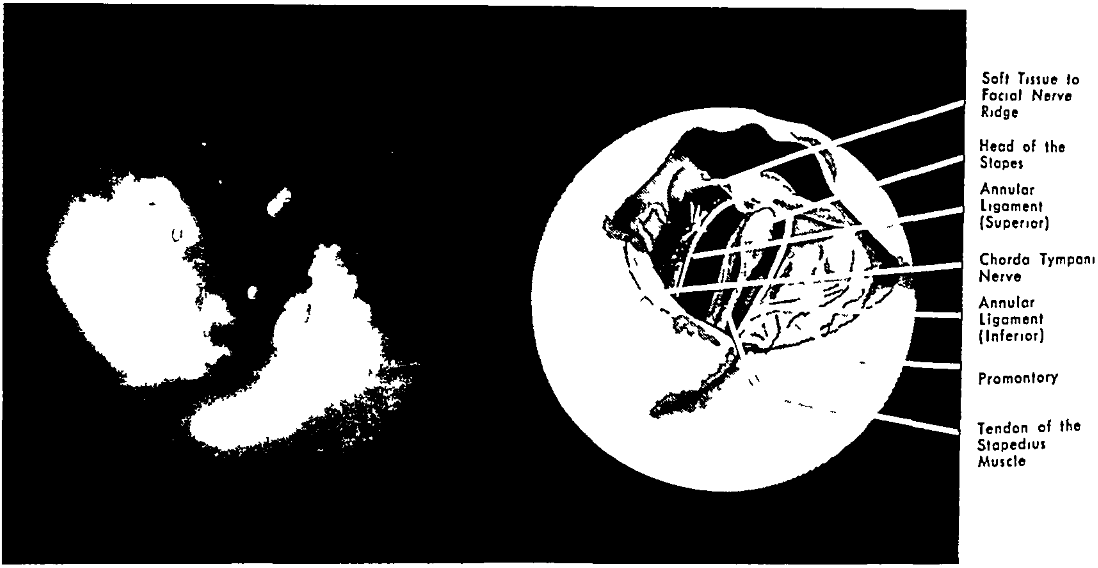
Soft Tissue to Facial Nerve Ridge
Head of the Stapes
Annular Ligament (Superior)
Chorda Tympan
Nerve
Annular Ligament (Inferior)
Promontory
Tendon of the Stapedius Muscle

Figure 2

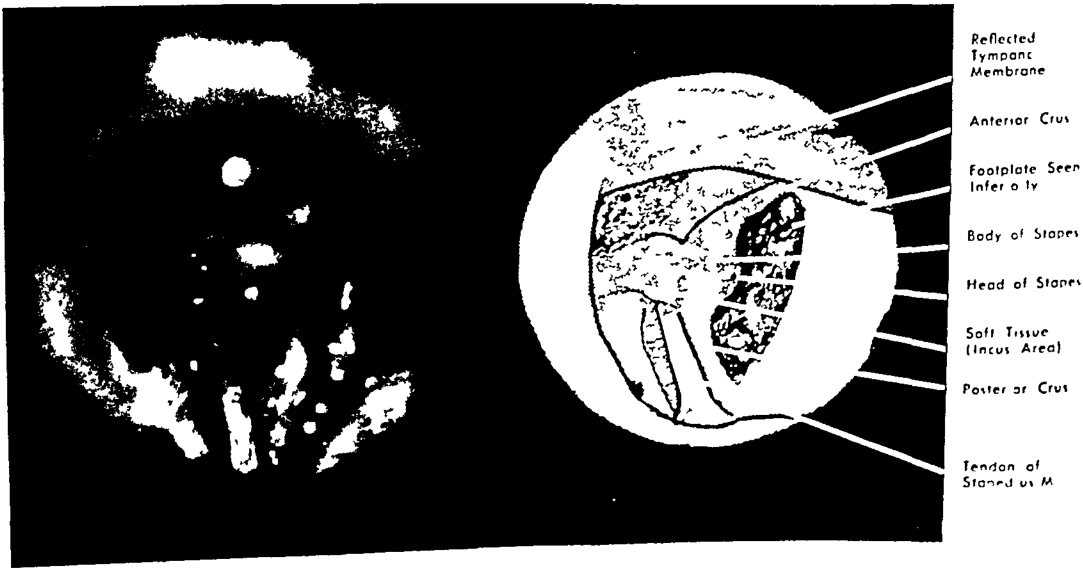

Figure 3

Figure 21

This is a photograph of the very simple procedure of obtaining a large curette full of bone from the edge of the posterior superior canal wall The bone will then be used as an autogenous bone graft to restore continuity of the long process of the incus and the head of the stapes as has been here described and illustrated

Figure 22

Photograph of the left middle ear presented to show total congenital absence of the tendon of the stapedius muscle and pyramidal eminence

The author has now observed nine cases of this anomaly There apparently has been no gross loss of hearing or adjustment as a result of this absence This does not mean that this muscle is useless Some of the finer aspects of human hearing may be lacking from the patient's experience

This is used as a closely allied example The incudostapedial joint may also be damaged and scarred and yet the hearing may be returned to near normal This seemingly normal function in spite of fibrosis should not encourage license to do damage to this important structure

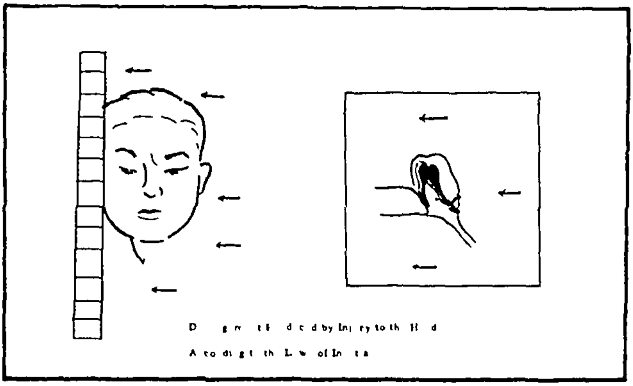

Figure 23

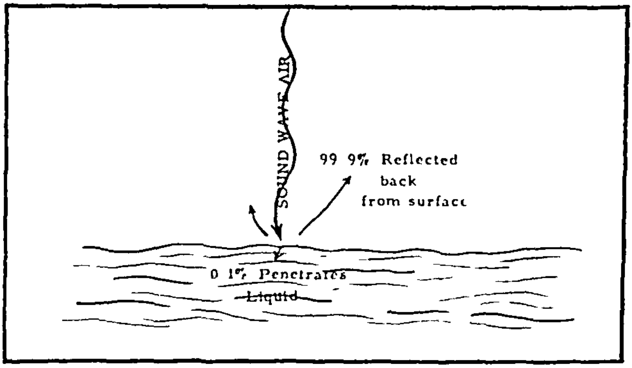

Figure 24

Figure 24
Diagram demonstrating loss of transfer of sound from air into fluid as a result of impedence factors

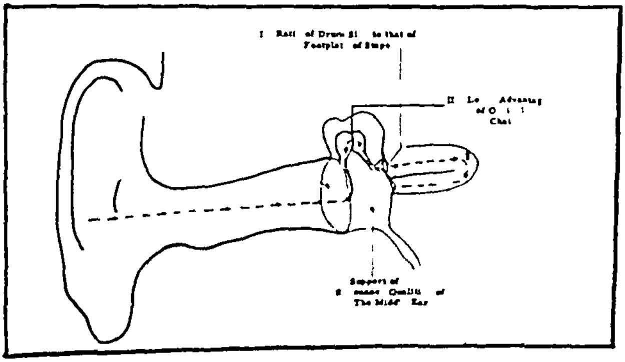
I Ratio of Drum to that of Footplate of Stapes
II Lever Advantage of Ossicular Chain
Support of Resonance Quality of The Middle Ear

Figure 25

Figure 25
Diagram demonstrating the important factors of the "transformer action" of the middle ear in the transfer of sound pressure energy from air to liquid

ficiency. Investigation is now under way to ascertain the fate of bone grafts in the middle ear.

A reasonable inquirer would desire to know how the normal, gliding smooth surface of the joint could be scarred, fibrosed, or perhaps ankylosed, and still allow almost perfect sound transmission through it. This operative restoration of hearing with such a fibrotic joint may give us a much clearer concept of the function of this joint. It is true, that the ability of the joint to transmit sound does not seem to be lost with intense scarring and perhaps ankylosis, but sound transmission is only a part of the function of the incudostapedial joint. In fact, this joint seems to be more of a juncture along the pathway of sound transmission at which sound conditioning may occur.

Frequently, we have considered this joint as nothing more than something to connect one ossicle with another so that vibratory energy might pass. It is the smallest joint in the human body. This, however, points not to its insignificance, but clearly to delicacy and fineness of purpose. I have observed nine cases of total absence of the stapedius tendon, one of which is demonstrated in the photograph represented by Fig. 22. These patients do not complain of an inability to hear simply because the stapedius tendon is missing. This means that grossly they do not need a stapedius muscle to hear, but some of the finer aspects of human hearing may be lacking from their experience. The stapedius muscle and the incudostapedial joint apparently hold a togetherness in the conditioning of sound as it passes toward the cochlea.

Heretofore, we have had the opportunity to test only animals under experimental conditions, but now we may learn much regarding the physiology of the middle ear by a careful analysis of these human cases with isolated defects.

SIGNIFICANCE OF INCUDOSTAPEDIAL JOINT SEPARATION

I. *Significance of Incudostapedial Joint Separation Due to Surgical Procedures*

The previous discussion and information in the literature regarding an incudostapedial joint separation incident to mastoid surgery speaks of its own significance without further elaboration [27,31]

Trans-incus and stapedial head maneuvers are still being used effectively to mobilize the stapes, but extreme care should be exercised *not to injure the incudostapedial articulation* (see Fig 6) A crushing fracture of the head of the stapes or lenticular process of the incus should be meticulously avoided, since these parts frequently necrose after fracture and produce pathologic separation of the two bones

Any surgical maneuver in the middle ear can cause accidental interruption of the ossicular chain, but in no procedure should one deliberately separate the incudostapedial joint simply because the operator might erroneously consider it to be unimportant

II Significance of Incudostapedial Joint Separation Due to Inflammatory Necrosis

Inflammatory necrosis of the long process of the incus may cause total incudostapedial joint separation (see Fig 8) This will cause a near 60 db conductive loss of hearing [13] This is very commonly encountered in the tympanoplastic repair of lesions produced by an old healed inflammatory process In most tympanoplasties, it is, therefore, important that the incudostapedial joint and the footplate of the stapes be exposed for microscopic functional examination This can be easily accomplished through an ordinary incision for a mobilization of the stapes Necrosis of the long process of the incus may be found in the presence of a normal tympanic membrane and without other significant damage of the ear [13]

III Significance of Incudostapedial Joint Separation Due to Head Injury

Evidence found in some of the cases presented here adds information to our knowledge regarding the effects of injuries of the head on the ability to hear Conductive deafness, due to ossicular chain damage, is a strong possibility in these cases (see Figs 9, 12, 15, Audiogram I) We now know that severe head injuries may produce

1 Cochlear damage alone as has been previously well emphasized [6,7 10 11,12,17,18 19,20 24,25,30]

2 Conductive deafness alone, as is seen in these cases of incudostapedial joint separation [13]

3 A mixture of both conductive and perceptive deafness (Audiogram III)

Many of these cases will present medicolegal problems involving a personal or an industrial liability claim (see Fig 13) Proper interpretation of test results combined with well planned surgical treatment will enable us more justly to assess and correct losses in these cases A loss of hearing immediately following a head injury, whether it be conductive or perceptive, must now be considered to be the result of that incident Before final disposition and after a reasonable time, exploratory tympanotomy should be done in *all* cases of otherwise unexplained conductive deafness, including those following injury of the head (see Figs 9, 12, 15)

IV *Physiologic Significance of Incudostapedial Joint Separation*

Many exceptionally brilliant thoughts have come to us by past publications that we may be enlightened as to the function of the foremost of all sound receivers—the human ear [3,21 23 35 36,37 38] In spite of the considerable amount of knowledge on this subject, otologists do not always understand or use this knowledge which embraces certain basic principles Despite functional significance, many of the present surgical procedures of the middle ear produce ossicular chain separation either deliberately or by accident

A brief statement as to the general function of the middle ear is that it receives sound vibration in air and transforms it to become sound vibration in fluid How this is accomplished has been the subject of much speculation in the past All authorities, however, generally agree, because of physical facts, that a transfer of sound vibration by air cannot be made directly into fluid without a marked loss of energy (see Fig 24) Only 0 1 per cent penetrates the fluid (see Fig 24), 99 9 per cent of this vibrating energy is lost or reflected back at the fluid surface This means acoustically that the sound in the fluid would be about 30 db less intense than in the air [21] This can be easily calculated by consideration of the relative impedance values of each substance

The primary function of the middle ear is that of a transformer mechanism which transfers the energy from the medium of air to the medium of fluid without loss of loudness

As we have observed, the transfer of air to fluid normally presents a near 30 db loss (see Fig 25) The middle ear overcomes this deficit in several ways The following are some of those methods used

1 The vibratory force of sound is exerted on a large tympanic membrane and is collected and transferred via the ossicular chain and concentrated on the smaller area of the footplate of the stapes This represents a gain of ratio between the two active areas of approximately 28 to 1 [21]

2 The ossicles are pivoted in a manner which provides a mechanical lever advantage of 1 3 to 1 5 1 This adds an additional 1 to 2 db

3 As a transformer, the middle ear has certain qualities of resonance of its own which exert an influence on the vibrating system of the ossicles to produce either a reinforcement or dampening of the vibratory energy passing through it This results in a most complicated combination since this resonant effect varies according to frequency and intensity Although these associations are complex, one may state definitely that the middle ear is amazingly well suited, in its own resonant properties, to perform this purpose of sound conduction and sound conditioning

The preponderance of evidence supports the theory that sound is collected by the tympanic membrane and transferred via the ossicular chain to the footplate of the stapes whereupon entry is made into the inner ear [21, 37] From time to time, there have been suggested theories which deny the pre-eminence of the drum and ossicular chain as the primary conductive route into the inner ear One extreme is the theory of hearing in reverse which proposes that sound penetrates the drum and goes through the round window into the cochlea. The ossicles and drum act as a protector. These thoughts all lead to the erroneous teaching that removal of certain sections of the ossicular chain is unimportant. It has been stated authoritatively that in the normal ear the vibrations entering the drum ossicular route have at least as much as 1000 times the energy of those entering by the round window.[21, 37]

Actually, to prove again the importance of the ossicular chain in sound conduction, one need only review the numerous animal experiments and physical data which have accumulated. I will mention three uniquely different experimental approaches to the analysis of the conductive mechanism.

1. Many authorities have carried out carefully controlled experiments on animals.[21, 37, 38, 39, 40] The incudostapedial joint was separated without disturbing the remainder of the middle ear mechanism. There was always produced a profound loss of approximately 60 db in the middle range of hearing when the incudostapedial joint was separated. The hearing levels in these cases were tested by using measurements from cochlear electrical potentials.

2. Evidence under another approach was that done by a physicist who utilized mechanical and physical laws to draw up a mathematical model of the ear.[23] From it, rather precise and amazingly accurate evaluations of the relative values of the components of the ossicular chain can be calculated. This mathematical formulation places a value of approximately 60 db upon a separation of the incudostapedial joint.

3. Work done by another authority on the condensor microphones has given us a technique that makes possible measurements by direct observation of movements of the vibration of the footplate of the stapes on the cochlear side.[3] One can also measure the vibrations of the tympanic membrane on its external side. In this microphonic device, one plate of the condensor is attached to the vibrating stapes, or tympanic membrane, while the other plate is fixed. The vibration alters the distance between the two plates and thereby produces a change in the copacetance of the condensor. Thus, the amplitude of the vibration can be easily measured. The effect of ossicular chain interruption on these amplitudes of vibration can be determined

These are only a few of the experimental methods by which the incudostapedial joint may be studied

From a practical viewpoint, information derived from patients presented here will add clinical evidence to that already obtained in previously experimental studies

Until recently, physiologic study of the incudostapedial joint has been confined to animal experimentation Patients presented here (see Figs 6, 7, 9, 10, 11, 12, 13, 14, 15, 16) represent human cases in which the importance of the incudostapedial joint can be studied directly This *in vivo* human evidence either *supports or denies certain assumptions concerning* the transmission of sound vibrations via the ossicular chain This evidence is well documented by actual photographs of each case, along with records of functional results before and after repair of the joint separation

Fig 10 is that of a classic incudostapedial joint separation[13] This patient had a unilateral purely conductive loss of 67 db for pure tone in the speech range and a 62 db speech threshold We must assume all of this loss to be purely and completely due to incudostapedial joint separation No other abnormalities of the external or middle ear could be found The tympanic membrane was normal and the malleus and incus moved easily The round window was normal The stapes was easily seen in its entirety and its footplate could be observed to move microscopically normally This cochlea had the opportunity to receive sound unimpeded through either the round window or the oval window There were no mechanical barriers at either window Both avenues of entry to the cochlea were perfectly normal, and all else concerning this ear was apparently in order, yet, there was a loss of 67 db in the speech range (see Audiogram I)

The only abnormality in this ear was a wide separation of the incudostapedial joint An incudostapedial joint separation, therefore, may categorically be said to cause a near 60 db conductive loss of hearing in the human ear

To emphasize this firm statement, we may observe the restoration of hearing in this patient resulting from a repair of the incudostapedial joint (see Fig 11, Audiogram II)

Repair of this joint alone was responsible for a hearing improvement Nothing else was done to the stapes or its footplate or any other portion of the ossicular chain or tympanic membrane which might have accounted for this improvement The gain must presumably be due only to the re-establishment of contact between the incus and stapes

In summary, by the use of several components, the middle ear acts as a transformer which overcomes about 30 db which otherwise would be lost in the transfer of sound energy from air to fluid If there is a gap in the chain across the transformer, such as is represented by the separated incudostapedial joint, not only the transforming action of 30 db is lost, but a short circuit of another 30 db is imposed This makes a total of a 60 db loss of hearing produced by incudostapedial joint separation

It is immmediately apparent that in this case it would be better to remove the transformer entirely and suffer only the 30 db loss in the transfer of sound from air to fluid Indeed, experimentally in those cases where the incudostapedial joint was separated, the hearing could always be improved by 15 to 30 db if the tympanic membrane and outer ossicles were removed This is the same as a system without a transformer

This then brings us rapidly to the conclusion that if there is an incudostapedial separation, the tympanic membrane and ossicles are not only useless, but, in addition, act as a soundproofing shield which absorbs and reflects vibratory energy, therefore, in a given case, if there is to be no provision for a solid ossicular chain between the tympanic membrane and footplate of the stapes, it is only logical that the tympanic membrane and outer ossicles be entirely removed! This, of course, is unreasonable and is mentioned only to emphasize the importance of maintaining the integrity of the ossicular chain It also points out that one must not remove an ossicle or disrupt a joint between two ossicles without making provision for the restoration of a solid pathway over which sound may travel from *the tympanic membrane to the footplate of the* stapes

Increased knowledge of tympanic physiology is accumulating rapidly Microscopic exploration of all areas of the middle ear has become extremely common in recent years Many of the surgical procedures cannot be routinely followed in a step-like fashion Due to the tremendous number of anatomical and pathological variations encountered in this area, operations must be individualized to meet the needs of each patient This is axiomatic in all tympanic surgery To repair the conductive mechanisms of the middle ear, therefore, one needs not an organized procedure in mind, but an understanding of the purposeful design of each component part of the mechanism Complete understanding may not be ours yet, for now we know in part, nevertheless, we see enough grandeur in what we do comprehend that we should never be tempted into disrespect for any portion of this beautifully created organ

SUMMARY

The etiology of incudostapedial joint separation may be on an embryologic, surgical, inflammatory, or traumatic basis

Repair of this separation may be accomplished by stapediopexy, repositioning, or autogenous bone graft Some suggestions in technique have been made

In the study of this joint separation, one is impressed by its frequency, its profound effect on the hearing, its physiologic implications related to all middle ear surgery, and its relation to a wide range of causative factors

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VETERANS OF FOREIGN WARS HONOR DR ALBERT P SELTZER

Dr Albert P Seltzer was selected and honored by the Veterans of Foreign Wars as the Man of the Year on May 20, 1959

COCHLEAR MICROPHONICS IN MAN

A Preliminary Report*†

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In 1930 Wever and Bray[6] first demonstrated the cochlear microphonic in cats. This phenomenon has been observed repeatedly in many species of animals, but there has been difficulty in recording the phenomenon in man. One of the earliest attempts was made by Fromm and his associates in 1935.[2] They were able to record only a small response in two cases. They used headphones to record the responses, and so no graphic records were obtained. In 1939 Andreev[1] and his group attempted to carry out further studies of the cochlear microphonic in man. Andreev was able to demonstrate the cochlear microphonic on the cathode ray oscilloscope with a maximum amplitude of 26 microvolts in one case, and a typical response of one to four microvolts. His larger responses were at 200 cps. Some of the intensities of sound used were noted to be painful. In 1941 Perlman and Case[5] published the first graphic record of the human cochlear microphonic. This response was barely above the noise level of the amplifier. Most of their records were made on unanesthetized subjects, by introducing the electrode through a perforation of the tympanic membrane. In 1947 and 1950 Lempert[3,4] and his associates reported further attempts to record this phenomenon. In 13 of 32 cases they obtained some response which was typically of low amplitude. In none of the studies reported

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were cochlear microphonics obtained that were comparable in amplitude or clarity to those obtained in working with experimental animals

After review of the foregoing information, it was decided that another attempt should be made to obtain human cochlear potentials which could be recorded at a level, and of a purity, to permit more extensive studies of human cochlear function These studies were carried out in the operating rooms of the Department of Otolaryngology, using the equipment, and under the supervision, of the Neurophysiological Laboratory of the Department of Otolaryngology

METHOD

Recordings were made in a general-type operating room under sterile conditions The room was quiet but not soundproof The subject was not shielded The wires from the electrodes were shielded, and as many as possible of the AC circuits in the operating room were turned off during the recording period There was no interference with the physiological signal

All stimuli were delivered to the exposed middle ear at the operating table Stimuli were *1* human whistle, *2* handclaps, *3* human voice, *4* tuning forks, *5* tones from an audio-oscillator The effective stimuli were of moderate intensity, far below tactile level

The recording electrodes in Cases H-1, H-2, and H-3 were made of 26-gauge Teflon-coated stainless steel wire with a small ball tip In Case H-4 a similar type of electrode was fashioned from platinum An indifferent electrode of the same material as that of the recording electrode was placed in the temporal muscle through a small stab-wound The subject was grounded by means of an electrocardiographic electrode applied to the shoulder nearest to the ear being tested The potential difference between the indifferent and the recording electrode was recorded The responses were amplified by a Tektronix 122 amplifier, which was connected to a Dumont 403-R cathode ray oscilloscope Graphic records of the responses were made with a Dumont cathode ray oscilloscope

Polaroid camera The traces were synchronized with the response The time-base and the amplitude are indicated in the lower right-hand corner of each figure

OPERATIVE PROCEDURES

Case H-1 B T age 12 white female, No 839291 Past history of chronic discharge from the right ear Clinical diagnosis chronic tympano-

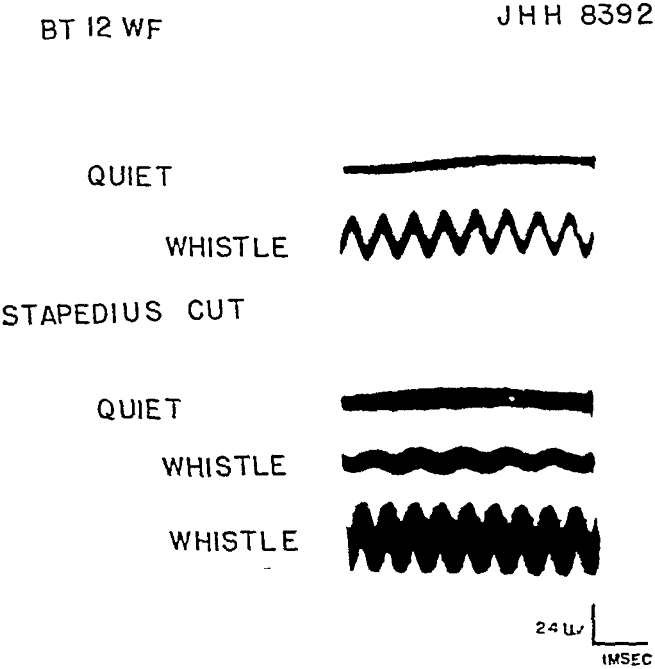

Fig 1 Case H-1 Response at the round window membrane to human whistle before and after section of the stapedius tendon

mastoiditis with secondary cholesteatoma arising from a marginal posterior superior perforation in the tympanic membrane A right endaural mastoidectomy was performed The cholesteatoma was found to extend into the aditus ad antrum and to have destroyed part of the body and the long crus of the incus Following the removal of the cholesteatoma a membrane of scar tissue could be seen external to the round window membrane After a small portion of the lateral margin of the round window niche was curetted away and the pseudo-membrane was removed a stainless steel electrode was placed on this membrane An excellent exposure of the round window membrane was obtained After a series were cochlear microphonics obtained that were comparable in amplitude or clarity to those obtained in working with experimental animals

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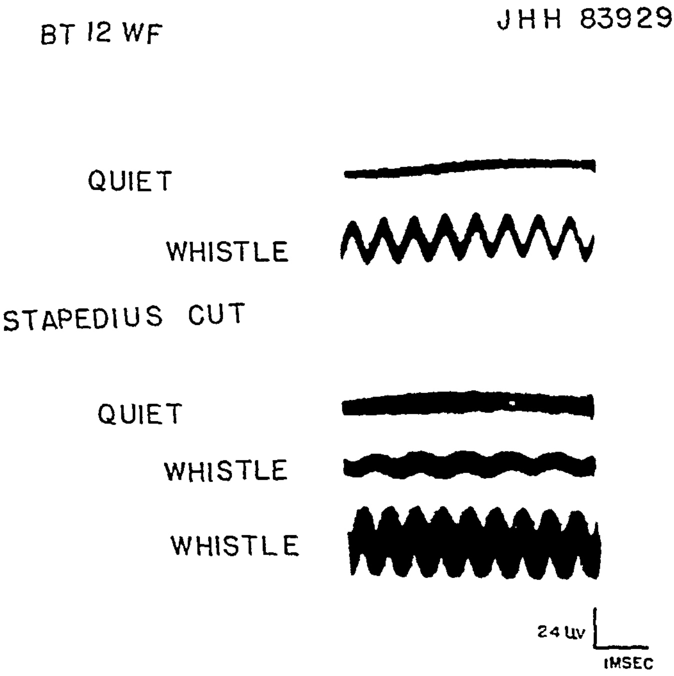

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Case H-2 E H , age 72, white female, No 840760 This patient had a history of vertigo, staggering to the left, and discharge from the right ear Clinical diagnosis chronic tympano mastoiditis with secondary cholesteatoma arising from a marginal posterior superior perforation in the tympanic membrane and labyrinth fistula The right middle ear was exposed by an endaural approach The cholesteatoma was found to occupy the attic and to extend through the aditus into the anterior portion of the antrum It had fenestrated the ampullar end of the lateral semicircular canal The stapes was embedded in thick scar tissue Some granulations were cleared away from the round window niche The round window membrane could not be visualized The stainless steel recording electrode was placed in the niche and minimal responses to sound stimuli were noted The electrode was shifted to obtain better approximation to the round window membrane Two or three drops of clear fluid welled out of the round window niche the round window membrane was thought to have been perforated No further attempts were made to obtain re

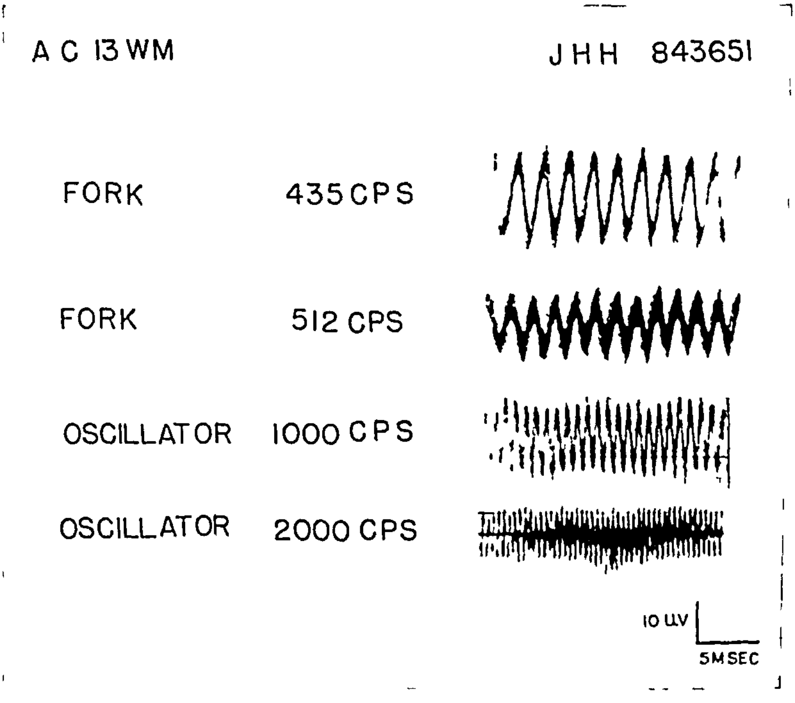

Fig 2 Case H-1 Response at the round window membrane to stimulation with various tuning forks and tones from an audio-oscillator

cordings The surgical procedure was terminated by a modified III-B tympanoplasty The patient had an uncomplicated postoperative course Her clinical symptoms improved Preoperatively she had a 40 db loss in the right ear, postoperatively it was slightly improved

Case H-3 M R, age 46 colored female, No 613659 This patient had a history of a right radical mastoidectomy in 1952 with subsequent chronic purulent discharge from the operative cavity When the cavity was revised the stapedial footplate was found to be embedded in granulations and scar tissue The crura had been destroyed The round window niche was filled with scar and granulation tissue After this was removed a portion of the lateral margin of the niche was curetted away in order to expose the round window membrane In spite of this, good visualization of the membrane was never obtained A stainless steel electrode was placed in the scar tissue in the niche with the ball tip pointed upward toward the membrane of the round window niche Using sound stimuli of human whistle and tuning fork, only minimal responses could be elicited Following the above, a Type IV-A tympanoplasty was done Postoperatively the patient had some nystagmus and vertigo, this cleared up in 48 hours A postoperative audiogram showed an average gain of 20 db in acuity

Case H-4 A C, age 14, white male, No 843651 This patient had a history of recurrent otitis media and a persistent small central perforation in the posterior superior quandrant of the right tympanic membrane The middle ear was exposed by creating a posterior tympano meatal flap, and by elevating the posterior portion of the fibrous annulus and folding the tympanic membrane forward The round window membrane was easily visualized The inferior portion was covered with a small pseudomembrane A platinum electrode was placed on the membrane Excellent cochlear microphonics were obtained in response to sound stimuli (see Fig 2) The recordings were followed by a transmeatal closure of the central perforation of the tympanic membrane The patient's postoperative course was uneventful Postoperatively, the hearing was improved

FINDINGS

Significant cochlear microphonics were obtained in two of the four cases In both of these cases the recording electrodes could be placed directly on a normal appearing round window membrane If the electrode was shifted to the bone surrounding the round window, the amplitude of the microphonic was greatly reduced In the two successful cases low intensity sounds such as whispered words, or spoken voice in the operating room could be readily visualized on the cathode ray oscilloscope In these cases the human cochlear microphonic was similar to that obtained from a cat

In Case H-1 (Fig 1), a 36 microvolt response was obtained from a high-pitched human whistle Following section of the stapedius tendon, a whistle of approximately the same intensity gave a 42-microvolt response A low pitched whistle gave a 6 microvolt response following stapedius section

In Case H-4 (Fig 2), sound stimuli were presented by means of tuning forks an audio-oscillator, and human whistle The 435 cycle tuning fork elicited a 25 microvolt response The 512 cycle tuning fork gave a 20 microvolt response A 1000-cycle tone produced an 18 microvolt response A 2000-cycle tone produced a 12 microvolt response

We had no accurate measurement of the sound input Some estimate can be made from the fact that the human whistle was presented by the operator through a standard face-mask from approximately two inches The tuning forks employed were steel, they were activated by striking them against the operator's elbow, which was padded by a gown The tone from the audio-oscillator was delivered through a brass tube approximately 2 cm in diameter, 25 cm long, placed approximately two inches from the ear At no time during the recording did the forks or the speaker come in contact with the subject Without more accurate measurements of sound intensities, we cannot make generalizations regarding cochlear sensitivity

In order to evaluate further the order of sound-pressures employed, a cat was anesthetized, the middle ear exposed through the bulla, and the platinum electrode used in H-4 was placed on the round window membrane The tympanic membrane was partially excised and sound stimuli were presented to the cat's ear, using the same tuning forks and audio-oscillator Comparable cochlear potentials were obtained to those seen in Cases H-1 and H-4 When the stapes was fixed with dental cement, no satisfactory microphonics could be recorded with these sound sources

CONCLUSIONS

1 Cochlear microphonics in man were obtained at a level which permits more extensive studies on human cochlear function

2 Cochlear microphonics in man, as in the cat, would seem to be greatly influenced by the degree of fixation of the stapes and the patency of the round window

3 To obtain satisfactory recordings of cochlear microphonics in man the recording electrode must have a good contact with the round window membrane

SUMMARY

During the course of four middle ear operations, attempts have been made to demonstrate the cochlear microphonic response in man In two of the four cases responses were

obtained, and recorded, that are like those yielded by the ears of experimental animals

ACKNOWLEDGEMENTS

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GILL MEMORIAL EYE, EAR AND THROAT HOSPITAL

The Gill Memorial Eye, Ear and Throat Hospital has just completed its Thirty-second Annual Spring Congress in Ophthalmology, Otolaryngology and allied specialties The attendance was one of the largest in the history of the school with an attendance of 350 physicians and their wives There were forty-two states, England, Canada and several foreign countries represented There were twenty-one guest speakers, sixty lectures and closed circuit televised surgery during the five and one-half days of the Spring Congress In 1960, the Thirty-third Annual Spring Congress will be held from April 4 through April 9

TYMPANOPLASTY *

GEORGE T HODGES, M D ,

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With the introduction of tympanoplasty by Wullstein and Zollner, great interest has centered on this phase of hearing restoration As Frenckner[1] has pointed out, "the solution of the great problems demand good teamwork, and it is justifiable that all who are intimately occupied with this problem, should present their views as support to the others, and as elements in the teamwork encompassing the entire otologic world" The purpose of this presentation, therefore, is to discuss various phases of this surgery in the light of obtained results

In considering this phase of auditory restorative surgery, we must alter our criteria, indications and mode of treatment Where the patient retains adequate cochlear reserve, every effort should be made to restore the hearing acuity, and in the course of treatment, eliminate the underlying disease This, of course, excludes such contra-indications as osteitis of the labyrinthine capsule and cholesteatoma of the inner ear The conservative care, especially of cases with cholesteatoma or other dangerous pathology, should no longer be condoned

Zollner,[15] Wullstein,[12] Frenckner,[1] and many other authors, have considered the one-stage vs the two-stage operation Where the patient is suffering from acute infection, with danger to the general well-being, or with complications involving the meninges, lateral sinus or facial nerve, the immediate situation should be relieved, preserving as many of the middle ear structures as possible The infection can then be brought under relative control and the tympanoplasty procedure carried out as a second stage operation A critical view should be extended to excessive radical surgery in acute situations On the premise that operative measures remove

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*Read at the Meeting of the Western Section of the American Laryngological Rhinological and Otological Society Yosemite Valley Calif Jan 17 1959

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the underlying pathology, all other tympanoplasty operations are carried out as one-stage procedures

Obviously, every effort is exerted in the preoperative period to obtain the quiescent state Exhaustive efforts are made to eliminate the aural infection, but a draining ear does not deter from proceeding with the surgery Contributing nasal and pharyngeal disease is eliminated, and the general physical status is evaluated, and appropriate medical measures are instituted Mastoid films are often informative The hearing should be evaluated by pure tone audiometry and other methods to determine cochlear function The status of the ossicles and round window can often be determined with prosthetic patching, the "acoustic probe" of Zollner, and with damping prosthesis over the round window The function of the eustachian tube can be evaluated by inflation, autoinflation, the passage of dye solutions and the passage of contrast media with roentgenographic study.

Ascertaining the cochlear reserve is of utmost importance, but the other tests are less reliable, may produce a state of false security and distract from the execution of the exacting steps in producing satisfactory results Regardless of the preoperative appearance of the tympanic membrane and the results of the examinations, the status of the ear cannot be adequately determined until the time of surgical intervention A preoperative plan of procedure is determined, but in every case the surgical team and the patient should be prepared for the extension of the operation to any given type

Many specific cases could be mentioned to exemplify this concept, but this should suffice On one occasion, an individual was observed with small, dry central perforations bilaterally and no visible middle ear disease The cochlear function was adequate, and patching prosthetics improved the hearing acuity On each occasion, surgical intervention revealed cholesteatoma in the oval window niche, having destroyed the head and crura of the stapes, pressing on the medial surface of the tympanic membrane, and thus producing a "columellar effect" between the tympanic membrane and stapes footplate

With regard to the type and source of the skin graft, a variation of opinion is prevalent There is a great deal of discussion by the various authors (Pagett,[1] Guilford and Wright,[2] Wullstein,[12] Harris and Meadows,[3] House[5]), regarding the split thickness vs the full thickness skin Both the three-quarter split thickness and the full thickness grafts would provide the much-discussed superficial and deep vascular networks and the strength desired by Wullstein The post-auricular skin has been used exclusively in all of our cases, being readily available, almost free of glands and hair, and its corium contains only a few elastic fibers so that it does not shrink nor curl

The skin is made as thin as possible, and the edges are beveled One may err in not thinning the graft adequately, fearing that the trauma may be detrimental A great deal of pressure is exerted to force the excessive tissue between the blades of the scissors, and at no time has the failure been due to primary sloughing Where the skin is to be reflected on the adjacent external auditory canal, small wedges are removed from the periphery to avoid wrinkles

If the skin is obtained from elsewhere on the body, an endaural incision may be justifiable Where the graft is obtained from the post-auricular area, a second incision in the ear is not within the bounds of good surgical judgment When using the post-auricular approach, one should observe that the skin of the superior half of the post-auricular fold is tightly bound and not in excess, whereas, the skin of the inferior half of the fold is loosely bound and often hangs in folds behind the lobule, hence, a large "tear-drop" shaped incision is made, removing a large portion of the skin from the inferior three-fourth of the post-auricular fold The skin incision can then be extended superiorly so as to gain adequate exposure The perichondritis reported by Leland House[6] has not been encountered When properly made, the incision affords excellent visualization of all areas, and the extensive incision of Herrmann, as used by Zollner,[11] is considered excessive and unnecessary

Many otologists, especially in this country, prefer the transmeatal myringoplasty to the classical tympanoplasty Type I

This procedure was undertaken more than 70 years ago by Berthold and Tangemann, but was later abandoned[13] Wullstein has observed that the operation which solely closes the perforation, will often produce excellent initial hearing gain, with later deterioration due to scarring of old granulations In the early days of development, myringoplasty was carried out by the European schools On revision and re-evaluation of the unsuccessful cases, Kley found pathology in one or more of the five control areas as described by Wullstein On the basis of these findings, the tympanoplasty Type I has been used, and unsuspected pathology has been encountered in the majority of cases

The various steps of the Type I tympanoplasty are well documented, but several minor factors warrant further discussion The external auditory canal is enlarged to the extent that every portion of the annulus can be well visualized There is no hesitancy in removing a large portion of the anterior canal wall, and no effort is made to preserve the overlying skin The antral control should be as small as possible, just large enough to afford inspection of the mucosa and the antral contents The literature is misleading in this respect, causing some workers to produce a very large antral opening, which increases the possibility of perforation of the overlying graft, producing secondary mastoiditis Often, on thinning the posterior canal wall, a small cell is exposed This may serve as an antral control, and further investigation may not be necessary Solution is then passed through the perforation and suctioned from the antral opening, affording an impression of the status of the epitympanum and the patency of the additus ad antrum

Early workers de-epithelialized a small area of the tympanic membrane adjacent to the perforation, but the present concensus is to denude the entire surface Where the perforation approaches the margin, an adjacent two or three mm of skin is removed from the external auditory canal Zollner[16] often deflects the skin of the canal away from the annulus with the concept that the skin will later make better contact with the margins of the graft

If the annular attachment of the tympanic membrane is disturbed, the tension of the circular and radial fibers is lost, and removal of the epithelium becomes very difficult The incision should extend only through the stratified squamous epithelium, so as to avoid damage to the underlying nutrient vessels As Wright[11] has observed in his microscopic sections, the tissue removed consists of the outer stratified squamous epithelium and an equal thickness of underlying connective tissue Because of this loose attachment to the radial fibers, the skin can easily be dissected in one sheet from the periphery to the handle of the malleus and the margins of the perforation Along the handle of the malleus, the skin is firmly attached to the underlying periosteum, hence, great care must be taken in the dissection to avoid cellular remnants The entire sheet is then removed with one mm of the edge of the perforation

Loose bands of radial fibers may simulate islands of epithelium, but these should not be disturbed Frenckner[1] applies cautery with trichloracetic acid to suspected islands of epithelium, but this is considered unnecessary and can be destructive to the underlying graft bed

The control of the upper middle ear by the Shrapnell's membrane approach and the lower middle ear by the fenestra, as described by Wullstein, has been replaced by reflecting the tympanic membrane, as in the stapes mobilization

Consideration of middle ear pathology warrants a separate presentation, but since myringoplasty was mentioned, it may be well to discuss some of the conditions encountered in the Type I operation When the tympanic membrane is reflected so that the medial surface of the perforation can be visualized, it is not infrequent to find that a column of diseased tissue extends from the perforation to the promontory and often spreads to encase part or all of the middle ear structures This tissue can often be swept out as one sheet, to find that the underlying structures are covered with their own thin and healthy mucous membrane Stratified squamous epithelium can migrate down this column to the middle ear structures, hence, its removal is of great importance Fibrous bands and membranes often bind the ossicles and cover the round window niche Purulent secretions, filling the antrum and mastoid, were encountered in a clean, dry ear of long standing Cholesteatoma in various degrees of destruction and in many unusual areas has been seen On two occasions, ankylosis of the stapes was encountered with good results following mobilization

In the more extensive procedures, where disease and cholesteatoma are present near the stapes and in the posterior portion of the middle ear, great care must be exerted in the proper dissection of the area There is a consistent chain of perifacial cells emerging from the mesotympanum, lying lateral to the facial canal and inferior to the short process of the incus There is a second group of cells inferior and medial to the above, lying anterior to the facial canal at the level of the hypotympanum One should also bear in mind that the middle ear extends posteriorly, lying medial to the facial canal, forming the posterior tympanic recess

Where the disease is present in these areas, the facial ridge is taken down to the facial canal in its descending portion in the region of the middle ear The danger to the facial nerve in carrying out this dissection has been eliminated by the use of diamond burs The cutting strokes should be light, "brush-like," and never with the exertion of pressure A cholesteatoma involving this area may be removed *in toto,* but to circumvent the possibility of cellular remnants, the mucosa in its entirety is removed from the stapes or remaining portions thereof, and from the superior one-half of the middle ear, including the tissues of the posterior tympanic recess In performing the Type IV operation, this dissection produces an area of clean bare bone for the reception of the edges of the skin graft, the diseased tissue is removed and the secondary granulations, reported by Wullstein, have not been encountered

Wullstein[12] has suggested the introduction of a plastic columella to convert the Type IV procedure into the Type III Being skeptical of the introduction of foreign material into the middle ear, this procedure has not been carried out The Type IV operation has afforded such astonishingly good results that further consideration should be given to the per-disturbed, the tension of the circular and radial fibers is lost, and removal of the epithelium becomes very difficult. The incision should extend only through the stratified squamous epithelium, so as to avoid damage to the underlying nutrient vessels. As Wright[11] has observed in his microscopic sections, the tissue removed consists of the outer stratified squamous epithelium and an equal thickness of underlying connective tissue. Because of this loose attachment to the radial fibers, the skin can easily be dissected in one sheet from the periphery to the handle of the malleus and the margins of the perforation. Along the handle of the malleus, the skin is firmly attached to the underlying periosteum, hence, great care must be taken in the dissection to avoid cellular remnants. The entire sheet is then removed with one mm. of the edge of the perforation.

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Prior to the instillation of the gelatin, all bone dust and blood clot should be removed It is extremely important that every vestige of clot be removed from about the ossicles, the round window niche and from the external surface of the tympanic membrane If complete hemostasis cannot be obtained by the application of topical adrenalin, a hypotensive agent may be employed In applying the skin graft, firm pressure should be exerted to insure good apposition with the radial fibers and the annulus One should be able to discern the underlying structures from the outer contour of the graft In the Type IV, an opening is created in the graft slightly larger than the stapes footplate The skin is firmly pressed onto the promontory and the inferior surface of the facial canal The skin should be in direct apposition with the bone and the footplate visible in its entirety

If the entire cavity cannot be covered with the skin taken from the post-auricular area, many workers will secure additional skin from other sites The complete covering of the cavity with skin promotes early healing, but the additional time and surgical trauma involved in obtaining, thinning and placing of the skin outweigh this advantage After the skin graft has been firmly pressed into position, the cavity is filled with additional soaked gelatin pledgets A short length of one-half inch vaseline gauze is placed over the gelatin pledgets, carried through and packed into the external auditory meatus The last maneuver serves as an aid in regaining or enlarging the size of the meatus

The remaining skin overlying the mastoid process, upper cervical region and posterior surfaces of the lobule and auricle is widely undermined The auricle is then drawn forming of the Type IV, Cavum Minor operation, where the stapes is intact, as is advocated by Richtner[10]

The Type V operation is preferably carried out in two stages, but the operation has been done in one stage with good results If the operation is to be carried out in two stages, the fenestra is prepared down to the blue line After the cavity is healed, a large skin flap is reflected from the medial wall of the created cavity The bony cupola is then incised, lifted and removed, as was described by Lempert[8]

Good eustachian tube function is an absolute prerequisite to all tympanoplasty procedures For this reason, the eustachian tube is investigated in every occasion, regardless of the preoperative findings Bony obstruction of the isthmus, requiring opening with a drill, has not been encountered Where the tube is tight it is forcibly dilated with metal probes In the majority of cases, the eustachian tube can be adequately enlarged by the passage of graduated plastic bougies from the middle ear to the nasopharynx To maintain the patency of the eustachian tube during the healing period, Zollner[15] inserted an acrylic tube threaded with silk suture material The many disadvantages led to multiple modifications until the present method was evolved Polyethylene tubing is molded to conform exactly to the course from the round window niche to the vestibule of the nose Prior to surgery, adequate lengths of p-50 and p-60 polyethylene tubing are selected These are threaded with No 26 stainless steel wires, which serve as mold forms, and the threaded tubes can be molded to the desired shapes They are then immersed in boiling water for a moment followed by a cold water bath The stainless steel wires can then be removed and the polyethylene tubes will maintain the desired configurations A tube is selected, fastened to the end of a bougie and passed as one unit This type of insert is advantageous in that the tube is neither felt nor is it visible It is adequate in maintaining the patency of the tube, it allows for free drainage from the middle ear and, because of its conformity, it is self-retaining and cannot be extruded

The gelatin hyaluronidase antibiotic mixture, as described by Kley[6] in his early experiments, is now used in all cases

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COURS DE TECHNIQUE AUDIOMETRIQUE

The Faculty of Medicine, Paris France, will hold a Course in Audiometry, October 12-18, 1959, under the chairmanship of Prof M Aubry of the Clinic of Oto-Rhino-Laryngology The tentative program includes lectures on the scientific fundamentals, the technique of audiometry, discussions of the results and problems of interpretation, and round table discussions Professor Aubry will be assisted by MM les Professeurs Agreges J J Debain and R Maduro, les Docteurs P Aboulker, J Bouche, P Clerc, H Henriot, R Maspetion, J Pialoux, J Bouchet, M Burgeat, L Chevance, P-L Klotz, P Robert, B Vallancien, Mme S Borel-Maisonny, M le Professeur A Didier, MM R Chocholle, J-E Fournier, R Lehmann and A Molles The complete program will be ready in June, 1959 For further details write Secretariet Service Oto-Rhino-Laryngologique Pavillon Isambert, Hospital Lariboisiere 2 Rue Ambroise-Pare, Paris 10°), France posteriorly and sutured to the periosteum, this, too, aids in maintaining the size of the meatus Retention sutures are insinuated from the under surface of the skin over the mastoid eminence and upper cervical regions to the periosteum at the original suture line This draws the skin into position so as to regain the original post-aurical fold

Innovations have been and are still being instituted in the postoperative care Starting on the seventh postoperative day, the patient is advised to autoinflate until slight pressure is felt in the middle ear On the fourteenth day, the polyethylene tube is removed with improved middle ear aeration Late removal of the gelatin packing from the cavity has reduced the secondary infection and is conducive to rapid healing of the created cavity

A compilation of the postoperative results will be deferred, as the surgical technique is still in the evolutionary state, and the elapsed postoperative time is too brief In general, the results have been excellent, and this type of surgery lends much to the future

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The postoperative course was uneventful The ear drum now appears more translucent and moves with use of the Siegle speculum

Case 2—M B male age 7½, whose hearing in his right ear had been found defective in a school survey made two weeks previously was first seen on Jan 31, 1957 The parents and child had not been aware of any previous hearing loss or ear trouble He had had the usual childhood diseases and respiratory infections, including hay fever in the summer months Ordinarily he has not been a mouth breather, his tonsils and adenoids had not been removed

Examination revealed a moderate amount of mucoid nasal secretion and somewhat pale and swollen turbinates The antrums transilluminated well The tonsils and adenoids were only moderately enlarged The left ear drum appeared normal The right was dull and immobile The Rinné test was positive on the left and negative on the right The Weber was lateralized to the right An audiogram showed a conductive deficit in the right ear of between 35 and 40 db with the lower tones relatively unaffected A diagnosis of right chronic secretory otitis media was made and a tonsillectomy and adenoidectomy together with myringotomy and aspiration advised These were done on March 25 1957 No fluid could be aspirated from the middle ear Periodic hearing checks were advised and when examined again on July 7 1957 (3½ months later), the findings now suggested the presence of a primary cholesteatoma X rays of the mastoids revealed good pneumatization and cell clarity on both sides (see Fig 3)

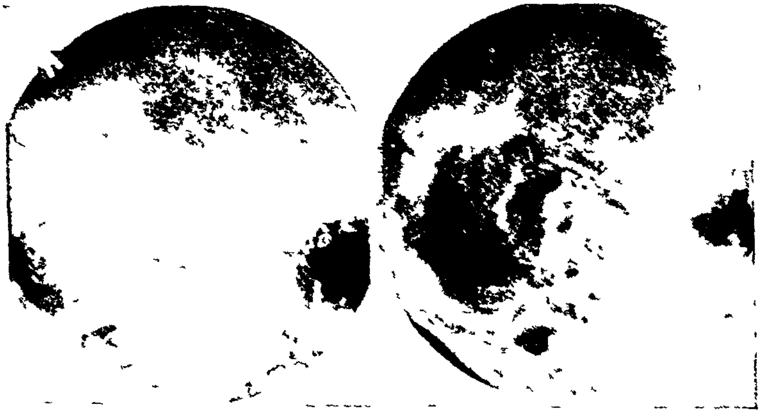

Fig 1 Case 1—Preoperative roentgenogram showing well pneumatized mastoids There is clouding of cells on the right, but their architecture is still intact

A stapes-type tympanotomy was advised and performed August 8 1958 The findings were quite identical to those described in the previous case The long process of the incus however, was found to be less eroded When some adherent cholesteatoma fragments in the hypotympanum were grasped the ear drum was inadvertently torn A piece of gelfoam saturated with Neo-cortef solution was then placed in the hypotympanum to hold the torn edges of the drum in closer approximation A myringostapediopexy was attempted utilizing the untorn portion of the drum

TWO CASES OF PRIMARY LATENT CHOLESTEATOMA DIAGNOSED AND TREATED BY TYMPANOTOMY

Discussion of Pathogenesis and Management of Cholesteatoma[*†]

HERMAN I LAFF, M D ,

Denver, Colo

The following two cases of primary cholesteatoma in children having well pneumatized temporal bones and without previous history or symptoms of otitis media seem worth reporting Both were referred after routine school surveys had shown a unilateral hearing loss

CASE REPORTS

Case 1—E P , female, age 9, came for examination on Feb 22, 1958, because a recent school test had shown a hearing loss in her right ear Neither patient nor her parents had been aware of any previous ear trouble She had had the usual childhood diseases and a tonsillectomy and adenoidectomy four years ago She has not been a mouth breather

Examination revealed an obviously healthy school girl with normal ear, nose and throat findings except those of the right ear The right ear drum appeared opaque and thickened, and lacked mobility Careful search failed to reveal evidence of perforation The Rinné test was negative in the right ear and the Weber was referred to that side

An audiogram showed a typical conductive hearing loss of about 40 db in the right ear in most frequencies, with a corresponding speech reception threshold of 40 The hearing in the left ear was normal Politzerization did not improve hearing Roentgenograms of the mastoids revealed well pneumatized temporal bones with some clouding of the cells on the right but with their architecture still intact (see Fig 1)

A presumptive diagnosis of primary cholesteatoma was made A stapes type tympanotomy was performed on March 28, 1958 The entire middle ear was found filled with cholesteatomatous masses extending toward the antrum and eustachian tube These were removed by the use of suction and forceps The middle ear showed evidence of encroachment and pressure atrophy, including destruction of the long process of the incus The intact stapes, which was covered with a thin layer of granulations, was *mobile* No evidence of ear drum perforation could be found The drum and its meatal cuff were replaced and invaginated onto the head of the stapes in an effort to produce a columella effect An appreciable hearing gain was thus obtained (see Fig 2)

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[*] Read at the Sixty-Second Annual Meeting of the American Laryngological Rhinological and Otological Society Inc Hot Springs Va Mar 10 1959

[†] From the University of Colorado Medical Center

Editor s Note This manuscript received in The Laryngoscope Office and accepted for publication Mar 19 1959

The postoperative course was uneventful The ear drum now appears more translucent and moves with use of the Siegle speculum

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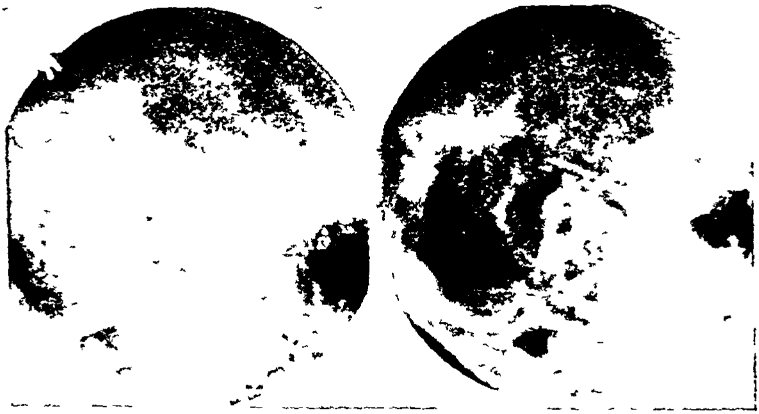

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It is now healed, shows areas of translucency and is fairly mobile An audiogram taken on October 9, 1958, showed moderate hearing improvement (see Fig 4)

DISCUSSION

Before embarking onto discussion, a word about terminology and the confusing classifications of cholesteatoma in general may help toward a better orientation of just what we mean by its primary type

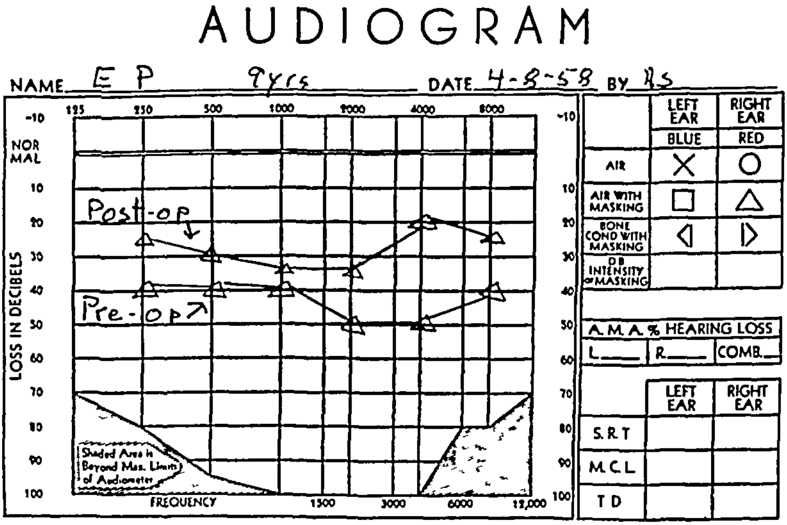

Fig 2 Case 1—Pre- and post-operative audiogram showing appreciable hearing gain following removal of cholesteatoma and myringo-stapediopexy

Dr Shirley H Baron recently emphasized that true cholesteatoma, or cholesteatoma verum—usually a neurosurgical problem—should not be confused with the primary type Texts have divided pseudocholesteatoma, which interests us as otologists, into primary and secondary, and then proceed to describe the common attic form with manifest perforations into Shrapnell's membrane as the primary type Recently the same term has also been used for cases without perforation, such as I have described Perhaps by adding a descriptive word such as *masked silent* or *latent*, to primary cholesteatoma, preferably the latter, there would be less confusion

That the enigmas concerning the pathogenesis of cholesteatoma and the related processes of temporal bone pneumatization still exist, was amply demonstrated by the spirited discussion they engendered at the recent International Congress of Otolaryngology at Washington As Ruedi[1] so aptly stated "An exact knowledge of the pathogenesis of cholesteatoma is essential for the successful application of our new surgical techniques"

It seems that Witmaack's teaching that otitis media of infancy by inhibiting pneumatization predisposes to chronic infections of the temporal bone, is still being challenged Ruedi prefers to believe that the relative lack of cells and sclerosis of the mastoid are not a cause, but a result of the chronic suppuration usually starting in early infancy

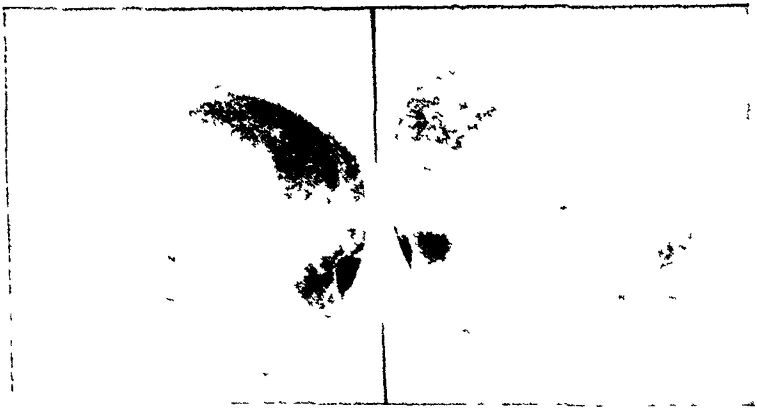

Fig 3 Case 2—Preoperative roentgenogram showing almost equal pneumatization and cell clarity of both mastoids

Diamant's[3] studies have impressed him with the hereditary and prenatal factors in pneumatization

Tumarkin[4] believes that frustration of pneumatization is dependent on a mechanical intratympanic vacuum created by continuous tubal closure, the result of chronic nasopharyngitis and adenoid hyperplasia in childhood

The view that implanted embryonic cell rests in the attic may form epidermoid cysts has also been proposed The occasional true cholesteatoma occurring sporadically in the diploe of the cranial bones does seem to originate in this manner Very few, however, now strongly support this theory for the origin of the common type of attic cholesteatoma

Bezold's hypothesis that chronic tubal obstruction may lead to collapse and rupture of Shrapnell's membrane, followed by superimposed infection and otorrhea has also received varying acceptance

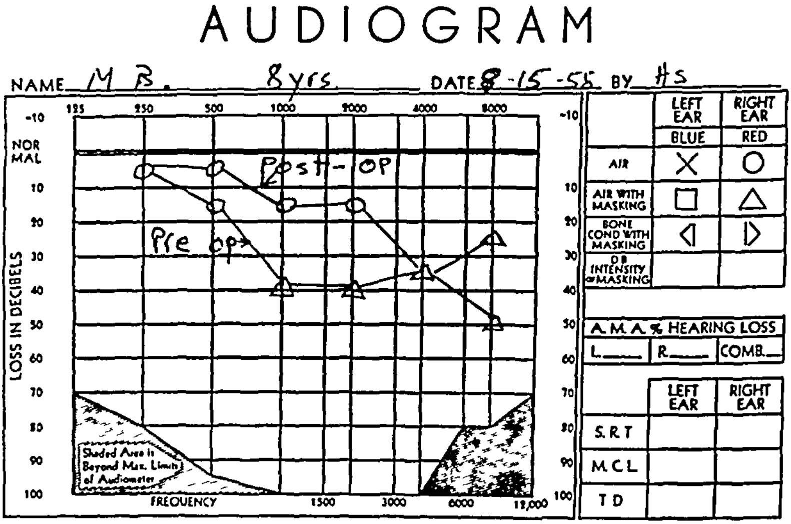

Fig 4 Case 2—Pre- and post-operative audiogram showing moderate hearing gain following removal of cholesteatoma and myringo-stapediopexy

Tumarkin's contention that the cuboidal epithelium of the attic could change to squamous type by an infectious metaplasia, was attractive in explaining primary cholesteatoma He now no longer defends this view because of recent experimental evidence to the contrary[4]

Clinical and pathological observation over the years have amply confirmed the belief that squamous epithelium from the external auditory meatus or tympanic membrane can migrate into the tympanum through marginal perforations, the result of necrotizing otitis media Seldom, however, have otologists actually seen the small marginal perforations originating and developing in Shrapnell's membrane during acute otitis media This "missing link" has naturally cast some doubt on the validity of the classical immigration theory Nevertheless, Ruedi[2] has histologic sections of embryos and young infants which show more than normal accumulation of hyperkeratotic epidermis of the upper drum margin He believes that, as a result of recurrent low grade inflammation of the tympanum in childhood, basal cells of the intact pars flaccida "can multiply and grow into the submucous connective tissue filling the incompletely pneumatized attic, or into newly formed granulation tissue, where they continue to grow into a cholesteatoma" Thus, although having formed behind an intact tympanic membrane, the cholesteatoma usually perforates it early, giving rise to a small upper marginal perforation

Recent experiments on guinea pigs tend to confirm this view Friedmann[5] placed pathogenic bacteria into their middle ears and was able to produce perforations of their ear drums followed by typical cholesteatoma formation Ruedi[1] has succeeded in producing cholesteatoma in guinea pigs behind their intact tympanic membranes (which interests us especially) by use of mild irritants (mixture of talc and fibrin) In man, however, histologic proof of primary cholesteatoma formation behind a still intact ear drum has apparently not been reported Likewise, relatively few primary cases have been found clinically Day,[6] House,[7] and DeWeese[8] each have recently reported such a case in adults

Summarizing, no matter what theory of origin the nonpartisan observer leans toward, each theory presupposes that inflammation still is the all-important ingredient needed to activate attic cholesteatosis

For a better understanding of the primary type, just what happens, especially in the early phase of a developing cholesteatoma and its matrix can be very informative

The matrix, according to Ruedi,[1 2] manifests infiltrative qualities early in its efforts to seek out and replace the hyperplastic connective tissue remnants in the middle ear cleft

Simultaneously, osteogenesis is also stimulated When submucosal tissue has been replaced these early activities cease The cholesteatoma then grows and expands by desquamation and infection at the expense of the surrounding bony walls, leading to complications all too familiar

Primary latent cholesteatoma, it would seem, could result from disturbances of its early, typical growth pattern Perhaps the ingrowing epidermis from the intact tympanic membrane becomes primarily attracted towards the newly formed granulations of the ossicles and tympanum This could be encouraged by abnormal disposition of connective tissue or presence of strategically placed limiting bands and spaces in the attic Thus Shrapnell's membrane fails to perforate

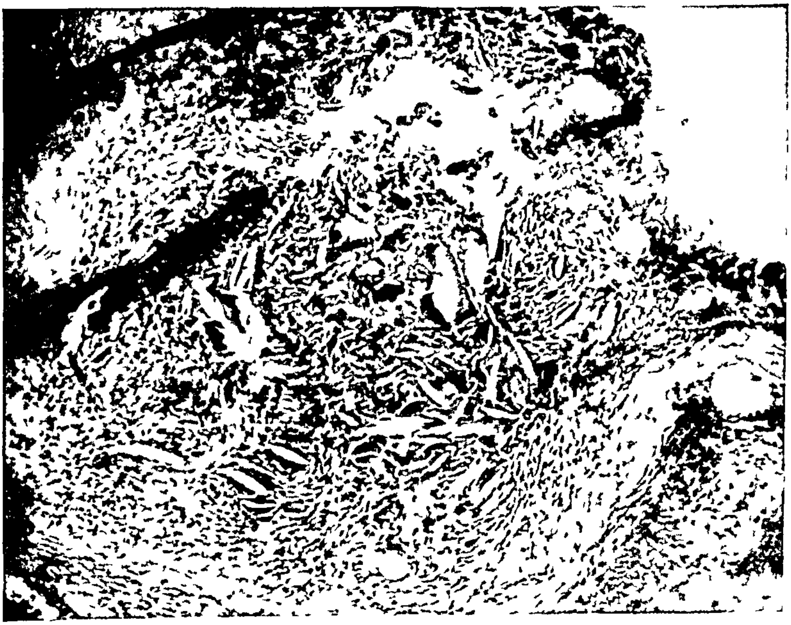

Fig 5 Cholesterin granuloma from a case of chronic mastoiditis showing granulation tissue containing cholesterin clefts foreign body giant cells and histiocytes

Since cholesteatoma generally starts insidiously its possible association with the currently rampant masked forms of otitis and mastoiditis has been brought to the fore Although in the majority of the latter, the usual forms of non-specific inflammation have been found, in some there have been uncovered groups of cells under the cortex filled with blackish material and granulations full of foreign-body giant cells, histiocytes and cholesterin clefts The latter represent dissolved cholesterin crystals (see Fig 5) Some English authors[9, 10] have looked upon these so-called cholesterin granulomas as precursors of attic cholesteatomas They have been found in mastoids with and without attic cholesteatoma As a rule, when both were present they were often remote from one another

The once rare but now more commonly found "blue drum" syndrome or hemotympanum has also been included in the picture of cholesterin granuloma The mastoid cells contain similar vascular granulations and slimy fluid discolored by hemosiderin Incidentally, these must be thoroughly removed surgically for effective cure

Whether cholesterin granuloma and attic cholesteatosis have a cause and effect relationship apparently has not yet been satisfactorily demonstrated The finding of cholesterin clefts in granulation tissue, pathologists tell us, is a common foreign body reaction and is not confined to the temporal bone Matrix in close proximity to the cholesterin granuloma has not been described Similar granulomas have been found in pseudocysts developing in old radical and fenestration cavities In my experience cholesteatomas have not resulted from these granulomas

For the present it would seem well to keep an open mind toward these newer concepts This may imply earlier surgical management of latent middle ear and mastoid infection, including those occurring in cellular temporal bones Thus, Burrell,[9] of Edinburgh, found that close to 50 per cent of his cases of attic cholesteatosis in children occurred in pneumatized mastoids

Today more "silent" attic granulations and perforations are being seen in children than say 15 or 20 years ago One naturally wonders if this could be tied to the present increased incidence of fluid ears Thus the removal of a speck of cerumen adjacent to Shrapnell's membrane will often disclose a small attic granulation and perforation leading into a cholesteatoma pocket Often there had been no history of previous drainage from such an ear In some, treatment for secretory otitis by myringotomy and aspiration had produced no improvement One can assume that such cases in essence were "primary" cholesteatomas for months or years, until break through revealed their true diagnosis In the two cases reported, the course was quite similar except that neither drum had perforated

When cholesteatoma develops in sclerotic mastoids it tends to be confined to the attic and antrum areas by the hemming in effect of the dense bone, it also tends to become encapsulated by its matrix and gives the appearance of a cyst This is a common finding, and the surgeon who chooses to preserve the matrix of such a cyst would appear to be on fairly safe ground Where cholesteatoma develops in a diploic mastoid, one can expect to find finger-like extensions of matrix penetrating into deep-lying cells These obviously should be meticulously sought for and removed

What changes a growing cholesteatoma will produce in a well pneumatized mastoid, may be inferred from findings of previous radical mastoid procedures Thus it could destroy the thin cellular partitions and occupy almost the entire mastoid process—a not uncommon finding (how this could have happened in a relatively short time in a child's sclerotic mastoid had been difficult to explain) , or the cellular architecture could be crowded out by osteogenetic activity, thus converting it to a diploic type This may be occurring in the case with cloudy cell outlines

I chose to perform tympanotomy as a means of proving that cholesteatomas were present and of removing them, if possible I suspect that they may recur as matrix may have been left behind

It is significant that others are now recommending conservative measures in management of early cholesteatoma Tumarkin[4] recently reported encouraging results with attic polypectomy and removal of epithelium from the borders of the perforation, together with curettement of its bony margins He used local anesthesia and magnification In this way he could halt the epidermic invasion which had just begun at the surface

Ruedi[2] proposed preventive antro-atticotomy with removal of connective tissue layers in the epitympanum in cases of recurrent infantile acute otitis media

In well established types of cholesteatoma, however, most will agree with the latter's dictum that "the complete removal of the matrix, of all cell systems and all connective tissue contained therein is necessary"

SUMMARY

Two cases of primary "silent" cholesteatomas in children having well pneumatized temporal bones have been presented The latter finding helps to divert our thinking from an hitherto ingrained belief that cholesteatoma necessarily goes hand in hand with diploic or sclerotic mastoids

Theories regarding pneumatization of the temporal bone and pathogenesis of cholesteatoma have been reviewed, especially as they relate to the primary type of cholesteatoma

Disturbances in the early growth pattern of cholesteatoma and its matrix which may result in lack of tympanic perforation have been discussed

The possible relations of cholesteatoma to the masked forms of otitis and mastoiditis, cholesterin granuloma and hemotympanum have been considered

Exploratory tympanotomy as a means of diagnosis of primary latent cholesteatoma has been advanced The definitive value of tympanotomy in treatment, however, is as yet unproven but is worth trying in selected cases

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227 Sixteenth Street

SOUTH CAROLINA SOCIETY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

The next joint annual meeting of the South Carolina Society of Ophthalmologists and Oto-laryngologists, and the North Carolina Eye, Ear, Nose, and Throat Society, will be held in Charleston, South Carolina, September 13-16, 1959 Headquarters will be the Francis Marion Hotel Guest speakers will include Ophthalmologists Dr Caroll R Mullen of Philadelphia, Pa, Dr G Bonaccolto of New York, and Dr Willis S Knighton of New York, Oto-laryngologists Dr John Bordley of Baltimore, Md, Dr Frederick R Guilford of Houston, Tex, and Dr Paul Holinger of Chicago, Ill

For further details write Roderick Macdonald, M D, Secretary and Treasurer, 330, East Main St, Rock Hill, S Car

OVAL WINDOW AND ROUND WINDOW SURGERY IN EXTENSIVE OTOSCLEROSIS

A Preliminary Report [*][†][‡]

WILLIAM F HOUSE D D S , M D ,

Los Angeles, Calif

The conquest of hearing loss due to otosclerosis is one of the most fascinating and unfinished parts of otology The unsolved problems of otosclerosis call for continued search for medical and surgical methods of alleviating the handicap caused by this disease

It is the purpose of this paper to present a method of opening the oval and round windows in cases of extensive otosclerosis

OVAL WINDOW SURGICAL TECHNIQUES

Stapes mobilization as proposed by Rosen[1] was a method of fracture through the otosclerotic focus of the oval window by pressure through the head and crura of the stapes

Later footplate techniques developed by a number of surgeons have made it possible to mobilize the majority of otosclerotically fixed stapes, however there still remain those patients with extensive otosclerosis in whom the thickness of the footplate is so great that it cannot be mobilized with any of the currently used needle, chisel or gouge techniques The next logical step, therefore, seemed to be the development of a method of removing this thick otosclerotic bone

The most practical method developed to date involves the use of diamond stones These are used in a dental handpiece and are about the size of a No 2 round bur. The cutting

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[*] Read at the Meeting of the Western Section of the American Laryngological Rhinological and Otological Society Inc Yosemite Valley Calif Jan 17 1959

[†] From the Department of Otolaryngology University of Southern California School of Medicine

[‡] Sponsored by the Los Angeles Foundation of Otology

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end consists of a number of small diamond chips embedded in an almost pure nickel binder Fig 1 shows the application to the footplate

The middle ear is exposed through the conventional stapes mobilization approach The stapedius tendon is severed and the stapes head and crura removed The thick otosclerotic

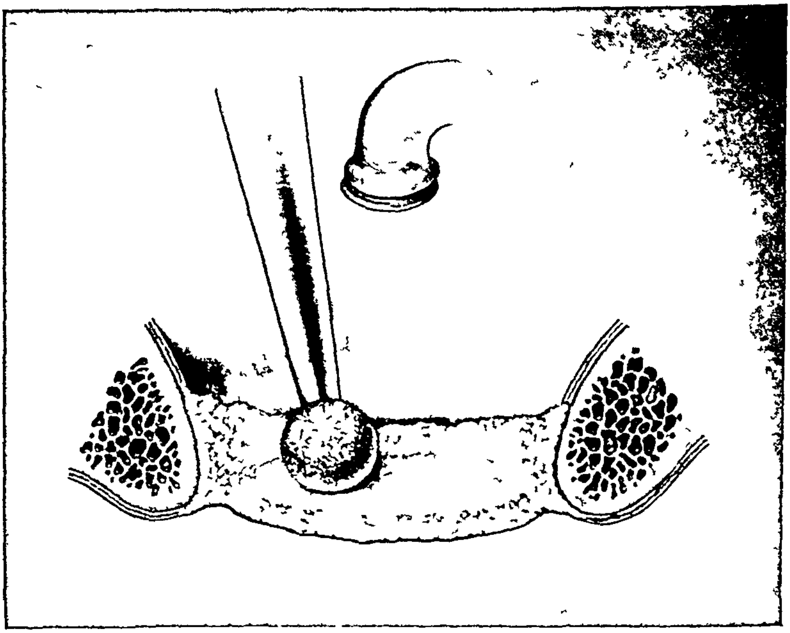


Fig 1

bone filling the oval window is then removed with a diamond stone The stone must revolve slowly, in order to avoid heat If the area becomes overheated the patient may experience a sensation of falling, due to utricular stimulation

Gradually the oval window area is thinned so that it becomes bluish in appearance A piece of No 90 polyethylene tubing is then shaped and fitted, after the method of Shea[2] from the lenticular process of the incus to the footplate, as shown in Fig 2

When the strut is properly fitted and placed, the thinned footplate is gently shattered by means of a chisel as shown in Fig. 3

RESULTS OF OVAL WINDOW SURGERY USING DRILL

To date we have operated upon six cases with the drill technique Three have 75 per cent or more closure of the air-bone gap, two have 25 per cent closure, indicating a significant hearing gain, and one is worse by 12 db, as averaged in the three speech frequencies On this last case the hearing was improved for two weeks and then decreased suddenly, apparently due to a displacement of the polyethylene strut

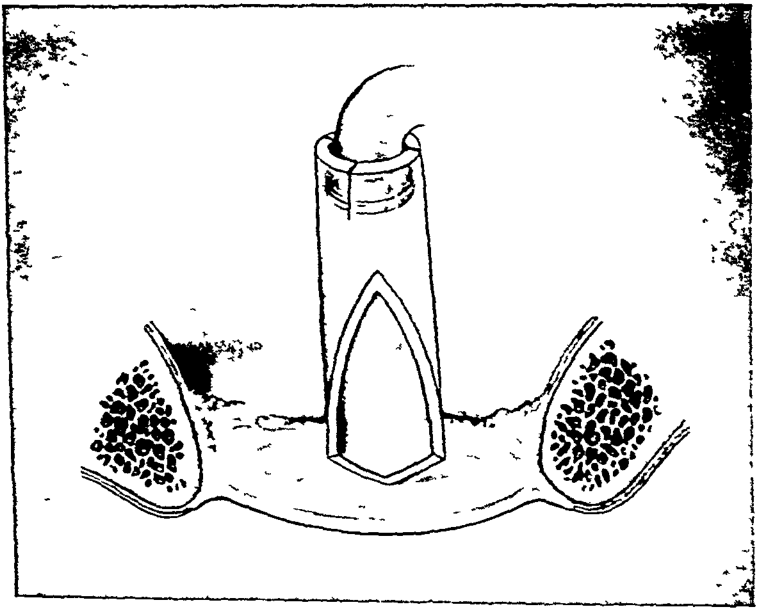


Fig 2

ROUND WINDOW OTOSCLEROSIS

The round window is the second most frequent site of otosclerosis [3] During stapes mobilization surgery this window should always be carefully examined Frequently it is seen to be partially occluded by otosclerosis Apparently, however, unless the window is completely occluded none of the hearing loss can be attributed to this factor [4] Nagai and Fraser[5] reported the histologic findings of six cases of total otosclerotic closure of both windows All had almost total hearing loss of a perceptive type

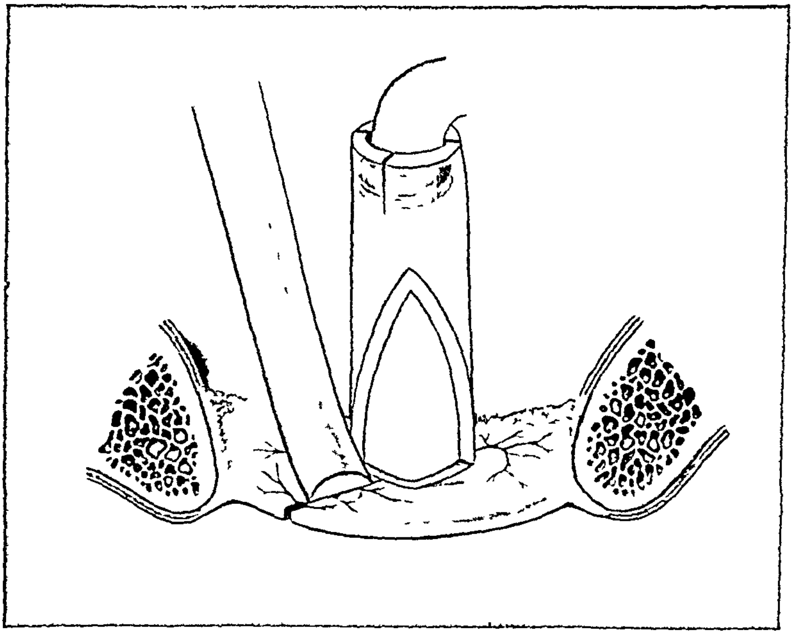


Fig 3

Since the diamond stone technique has made it possible to remove otosclerotic foci, we decided to see whether it was possible to improve hearing in far advanced otosclerosis by opening both the round and oval windows

RESULTS OF OVAL AND ROUND WINDOW SURGERY USING DRILL

To date we have results on six such cases four months or more following surgery The following is a summary of three represenative cases of round and oval window otosclerosis

Case 1 Mr B, age 46, developed his hearing loss at the age of 18 A diagnosis of otosclerosis was established in our office in 1946 At that time he had a conductive type hearing loss which was too far advanced for fenestration surgery

In February, 1958, he was again examined and at that time responded only to bone conduction at 55 db at the 500 ferquency in each ear No other bone or air conduction responses were obtained at the limit of the audiometer The patient was wearing a bone conduction aid, but was unable to understand any speech with the instrument

X-rays made by Dr Compere revealed extensive otosclerosis of both otic capsules

In June 1958, through an endaural incision, the left middle ear was exposed The oval window was almost obliterated by otosclerosis Only a small dimple in the mucous membrane remained marking the location of the former round window

The stapes head and remaining crura were removed The oval window was reopened with a diamond stone A vein graft taken from the hand was placed over the oval window, and a piece of No 90 polyethylene tubing was placed from the lenticular process of the incus to the vein graft after the method of Shea

The round window was then opened with the diamond stone It was found that a band of fibrous tissue embedded in bone led from the dimple on the promontory down to the former round window At the end of the procedure it was possible to see movement of the fibrous tissue in the round window area when pressing on the incus

Following surgery the bone conduction remained the same, but he now had air conduction responses at 90 db for the speech frequencies Using an air conduction aid his speech reception threshold was now 44 db

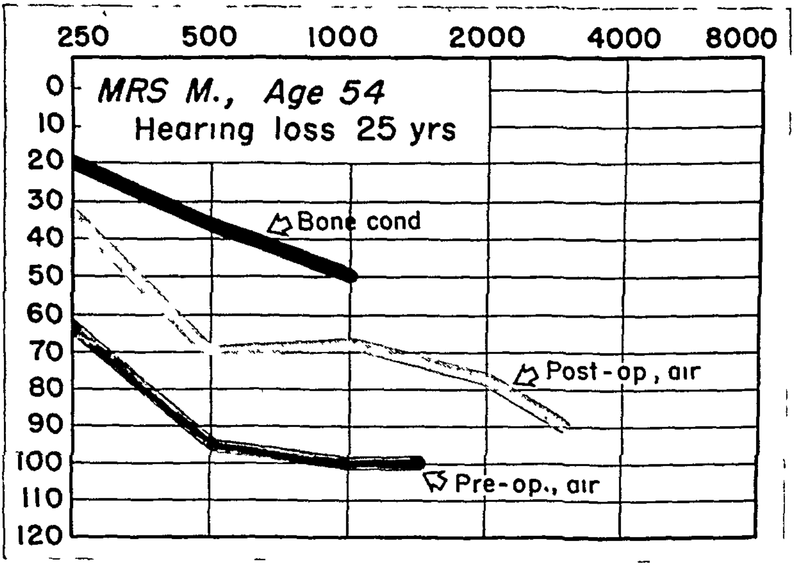
Following the above case, three additional cases with almost total deafness were done These cases were also done under general anesthesia, but a trans-canal approach was used This approach was found to give satisfactory visibility, and the surgery was shortened

Two cases obtained a similar improvement to the above and one had no improvement

Case 2 Mrs M, a 54 year old woman first noted hearing loss at the age of 19 Fig 4 shows the preoperative and postoperative audiograms

In October, 1958 under local anesthesia a trans canal stapes mobilization approach was used The round and oval windows were completely fixed by otosclerosis The oval window was opened with a diamond stone after removal of the stapes A vein graft and polyethylene strut were placed At this point a hearing test was taken and no improvement noted The round window was then opened with a diamond stone, and in this case it was necessary to open forward of the round window since much of the scala tympani was involved in the otosclerosis The window was considered open when perilymph escape was noted and when this showed pulsation with pressure on the incus The patient immediately stated that the spoken voice was clearer and her threshold improved

Postoperatively the patient was nauseated and dizzy for several hours but was able to leave the hospital the next day Her threshold improved by 30 db as shown in Fig 4 but the discrimination score dropped from 48 to 32 In addition, the patient could tolerate only 13 db of increased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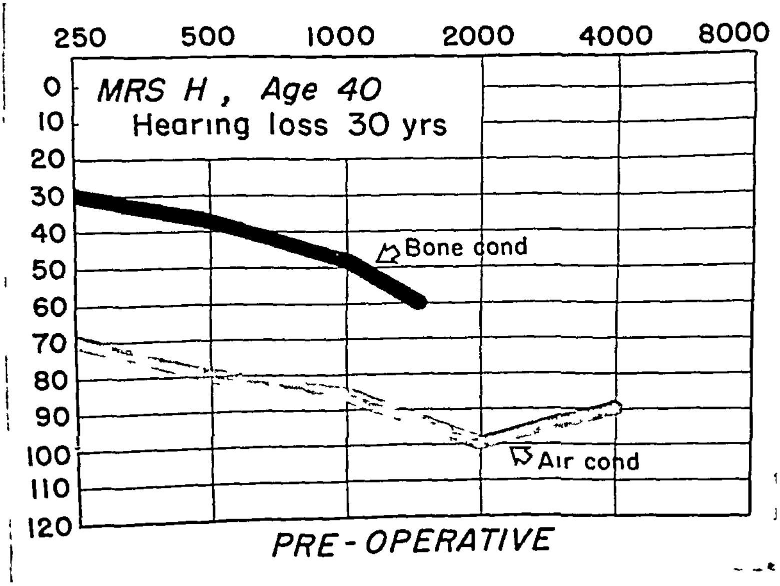
MRS M., Age 54
Hearing loss 25 yrs
Bone cond
Post-op, air
Pre-op., air

Fig 4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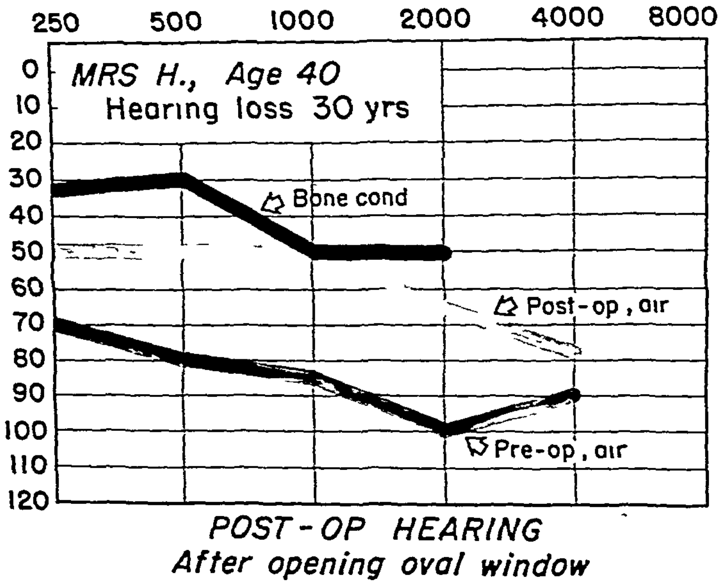
MRS H, Age 40
Hearing loss 30 yrs
Bone cond
Air cond
PRE-OPERATIVE

Fig 5-1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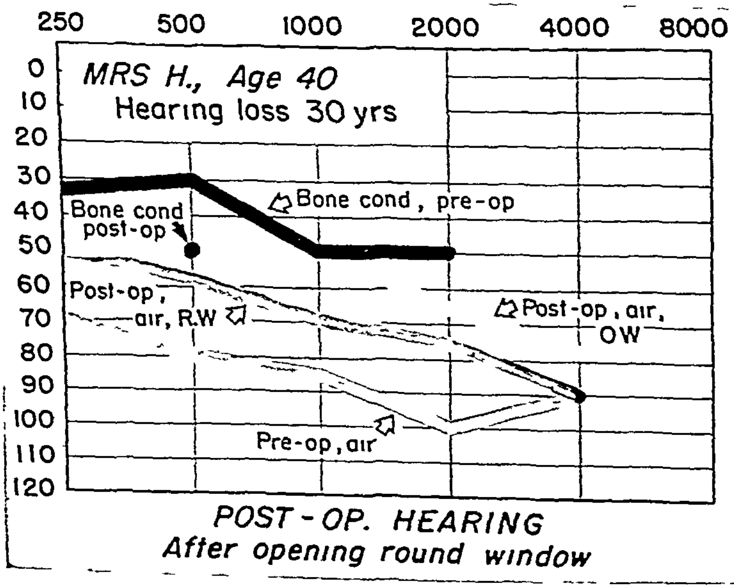
MRS H., Age 40
Hearing loss 30 yrs
Bone cond
Post-op, air
Pre-op, air
POST-OP HEARING
After opening oval window

Fig 5-b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MRS H., Age 40
Hearing loss 30 yrs
Bone cond, pre-op
Bone cond post-op
Post-op, air, R.W
Post-op, air, OW
Pre-op, air
POST-OP. HEARING
After opening round window

Fig 6

loudness During the past months this has improved considerably, but the patient still prefers to wear her aid in the opposite ear

In view of the results of the above case, it was decided to make a two-step operation out of the procedure The first stage would be to open the oval window and the second stage to open the round window It was felt that in this way less perilymph would be lost and less operative trauma would occur

Case 3 Mrs H, a 44 year old woman, first noted hearing loss at the age of 14 years Preoperative audiograms are shown in Fig 5

In November, 1958, the oval window was opened, using a diamond stone and a polyethylene strut No vein graft was placed This procedure resulted in a substantial gain in hearing

One month later, using local anesthesia and a stapes approach, the round window was opened This resulted in an immediate drop in hearing of 20 db, although the patient had no vertigo The next morning her hearing was back to the preoperative level, so it was assumed that the immediate operative loss was due to loss of perilymph

One month following surgery, however, the hearing level was down 10 db by air and the bone conduction decreased, as shown in Fig 6 In addition, the patient had decreased loudness tolerance

DISCUSSION

At present the exact clinical effect of closure of the round window is not known Wever and Lawrence[6] were able to show air conduction losses as great as 20 db below 1,000 cps, from closure of the round window in experimental animals They emphasize, however, that a displacement of only one-third of a cubic mm is necessary to give normal hearing, therefore, clinically, we must have complete bony closure to have any effect

Goodhill, et al,[7] in animal experiments, was able to show a loss of approximately only 10 db by bone and air for the speech frequencies by closure of the round window He is the only investigator to measure bone conduction in animals with closed round windows

Work to date indicates that round window surgery in far advanced otosclerosis is a worthwhile procedure The last two cases, however, indicate that in less advanced cases we must proceed with caution

SUMMARY

1 Regardless of the degree of otosclerotic fixation, the oval window can now be opened by means of a diamond drill technique

2 The round window can also be opened surgically, but further investigation needs to be done to establish the indications and contraindications of this procedure

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AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY HOME STUDY COURSES

The 1959-1960 Home Study Courses in the Basic sciences related to ophthalmology and otolaryngology, which are offered as a part of the educational program of the American Academy of Ophthalmology and Otolaryngology, will begin on September 1 and continue for a period of ten months Detailed information and application forms can be secured from Dr William L Benedict, executive secretary-treasurer of the Academy, 15 Second Street S W, Rochester, Minn Registration should be completed before August 15

RADICAL NECK DISSECTION

A Clinico-Pathological Study of 200 Cases *†

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WERNER MUELLER, M D ,
and
JAMES B SNOW, JR , M D ,
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In the evolution of otolaryngology, the radical neck dissection is a fairly recent development As short a time ago as 1956, one of us (G F R) reported 75 cases of radical neck dissection which had been done at the Massachusetts Eye and Ear Infirmary between the years 1948 and 1955 [7] Since that time there has been a marked acceleration in the utilization of this procedure in the treatment of cancer of the head and neck Coincident with the frequent utilization of this operation, one of us (W M) in his role as director of otolaryngic pathology at the Massachusetts Eye and Ear Infirmary, recognized the need and importance of a careful dissection and study of the surgical specimens from these operations Beginning in 1952, he initiated a time-consuming and painstaking study of each surgical specimen, in which each specimen on arrival at the laboratory, is carefully traced as to its outlines and landmarks, and a color photograph is made of each specimen After fixation, each specimen is carefully and laboriously dissected to remove all recognizable lymph nodes Indeed, this laboratory dissection of the specimen frequently takes as long or longer than the operation As the laboratory dissection proceeds, each identifiable node is drawn on the previously traced outline to show its exact location and size The nodes are classified anatomically as upper jugular, mid-

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*Read at the Sixty-Second Annual Meeting of the American Laryngological Rhinological and Otological Society Inc Hot Springs Va March 10 1959

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jugular, lower jugular, sub-mental submaxillary, spinal accessory, and supraclavicular Figs 1 and 2 demonstrate the photograph of the original specimen and the laboratory drawing made on arrival at the laboratory It will be seen that all dissected nodes are located in the drawings, and after the microscopic sections of each of these nodes are processed, positive nodes are marked accordingly to delineate them from non-malignant nodes These efforts in conjunction with the clinical material available in the patients' records in the ensuing years have yielded a series of radical neck dissection cases on which we have an unusually extensive amount of information, both as to clinical course and surgical-pathological data It is the purpose of this paper to present these findings

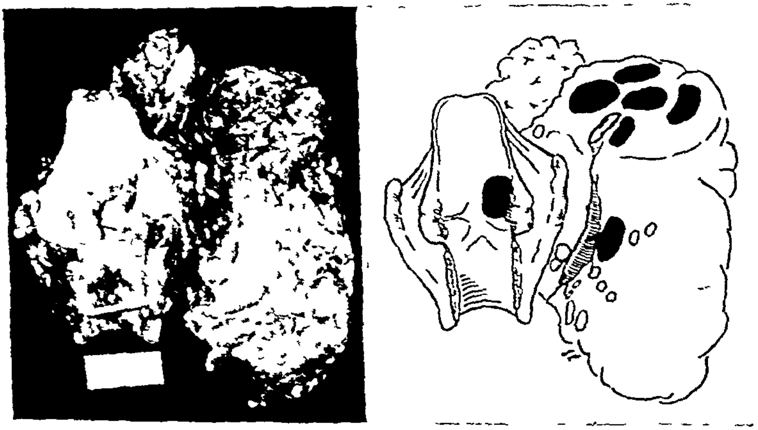

Fig 1

Of necessity much of the information presented will be of statistical value only with no immediate clinical application, nevertheless, we feel that the material is of sufficient importance to be recorded in some detail for possible future use

DESCRIPTION OF SAMPLE AND GENERAL OBSERVATIONS

Our sample consists of 200 unselected patients who had radical neck dissection between 1948 and 1958 Twenty-three of the patients had bilateral dissections, and, therefore, the pathological material consists of 223 neck specimens Seventy of the neck dissections were performed as combined procedures and 153 as delayed operations with a time interval between treatment of the primary lesion and the subsequent radical neck dissection There were 178 males and 22 females in the group Table I demonstrates the age distribution and, as expected, shows a predominance in the 50-70 year age groups

Table II depicts the distribution of the sample by site of the primary lesion It will be noted that the predominance of cases in this series originated in the laryngeal and hypopharyngeal region The classification of laryngeal and hypopharyngeal lesions for statistical purposes is still a matter of much debate, therefore, we are using an original classification based on the areas involved by the primary lesion This classification with the number of cases in each area is shown diagramatically in Fig 3 The areas illustrated are concerned, not with the region of supposed *origin* of the tumor, but with the areas *involved by* the tumor It will be noted that for clarity and ease of understanding 14 minor areas of involvement have been condensed into four main groups of involvement, *i e*, cordal-subglottic, vestibular, supravestibular, and

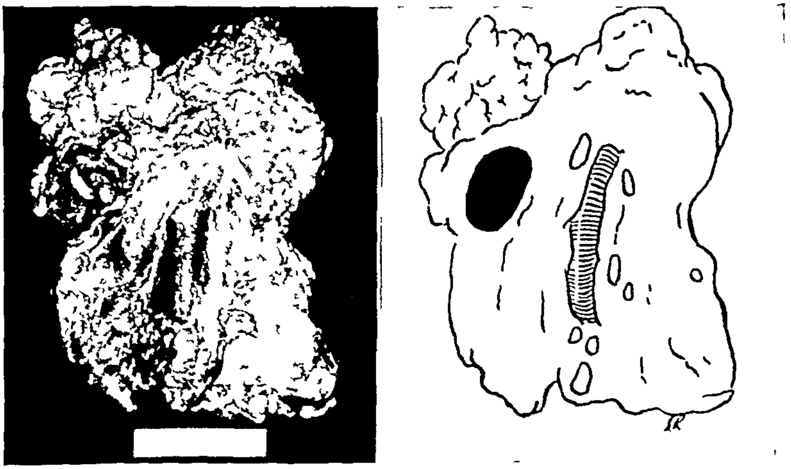

Fig 2

TABLE I

Sex	
Male	178
Female	22
Age	
30	0
31-40	5
41-50	28
51-60	72
61-70	69
71 80	24
81 90	2
Total	200

TABLE II

Classification of Site of Primary Showing Number of Cases in Each Area and Group

Area	Number of Cases		Area Involved	Group
A	9	21	Cordal	Cordal Subglottic
B	1		Subglottic	
C	11		Cordal and Subglottic	
D	6	31	Supracordal Endolaryngeal	Vestibular
E	18		Cordal and Supracordal Endolaryngeal	
F	7		Cordal and Supracordal Endolaryngeal and Subglottic	
G	12	61	Epiglottic	Supra vestibular
H	13		Base of Tongue	
I	19		Supracordal Endolaryngeal and Epiglottis	
J	10		Cordal and Supracordal Endolaryngeal and Epiglottic	
K	7		Epiglottic and Base of Tongue	
L	18	63	Hypopharyngeal	Hypopharyngeal
M	3		Hypopharyngeal and Base of Tongue	
N	42		Hypopharyngeal and Supracordal Endolaryngeal	
Other combinations	8			
Total laryngeal and hypopharyngeal		184		
	1		Nasopharynx	
	3		Eye	
	3		Nose	
	3		Ear	
	2		Parotid	
	1		Floor of mouth	
	3		Palate	
Total		200		

hypopharyngeal The *cordal-subglottic group* includes lesions involving only the true cords, lesions involving only the subglottic area, and lesions involving both the true cords and subglottic area The *vestibular group* includes lesions involving only the supracordal endolaryngeal area, lesions involving the true cords and the supracordal endolaryngeal area, lesions involving the true cords and the supracordal endolaryngeal area as well as the subglottic area The *supravestibular group* includes lesions involving the epiglottis only, lesions involving the base of the tongue only, lesions involving the supracordal endolaryngeal area and the epiglottis, lesions involving the true cords as well as the supracordal endolaryngeal area and the epiglottis, and lesions involving both the epiglottis and the base of the tongue

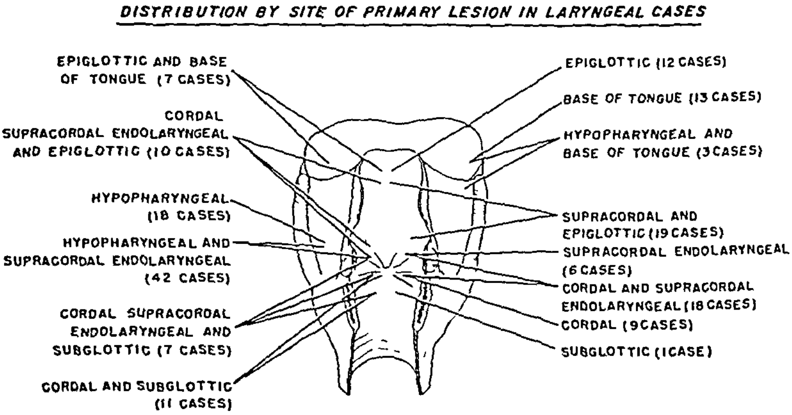
DISTRIBUTION BY SITE OF PRIMARY LESION IN LARYNGEAL CASES
EPIGLOTTIC AND BASE OF TONGUE (7 CASES)
CORDAL SUPRACORDAL ENDOLARYNGEAL AND EPIGLOTTIC (10 CASES)
HYPOPHARYNGEAL (18 CASES)
HYPOPHARYNGEAL AND SUPRACORDAL ENDOLARYNGEAL (42 CASES)
CORDAL SUPRACORDAL ENDOLARYNGEAL AND SUBGLOTTIC (7 CASES)
CORDAL AND SUBGLOTTIC (11 CASES)
EPIGLOTTIC (12 CASES)
BASE OF TONGUE (13 CASES)
HYPOPHARYNGEAL AND BASE OF TONGUE (3 CASES)
SUPRACORDAL AND EPIGLOTTIC (19 CASES)
SUPRACORDAL ENDOLARYNGEAL (6 CASES)
CORDAL AND SUPRACORDAL ENDOLARYNGEAL (18 CASES)
CORDAL (9 CASES)
SUBGLOTTIC (1 CASE)

Fig 3

The *hypopharyngeal group* includes lesions involving only the hypopharynx, lesions involving the hypopharynx and the base of the tongue, and lesions involving the hypopharynx and the supracordal endolaryngeal area These groups and the number of cases in each group are graphically shown in Fig 4

Wherever the site of the primary lesion is considered in our findings, we will present the abbreviated four region

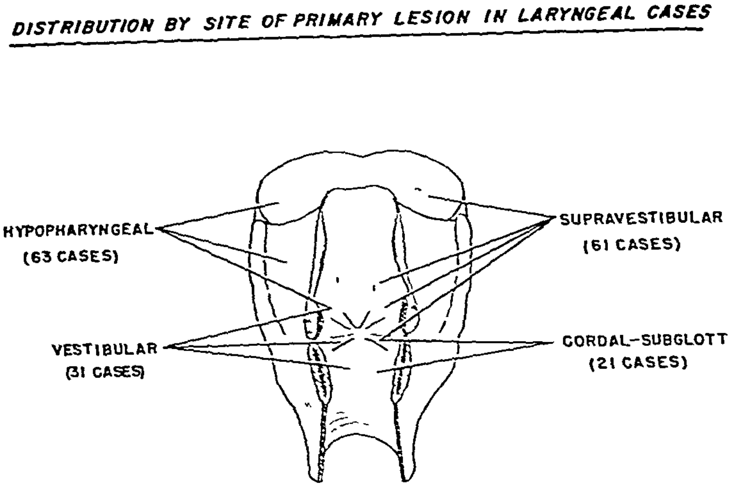
DISTRIBUTION BY SITE OF PRIMARY LESION IN LARYNGEAL CASES
HYPOPHARYNGEAL (63 CASES)
SUPRAVESTIBULAR (61 CASES)
VESTIBULAR (31 CASES)
CORDAL-SUBGLOTTIC (21 CASES)

Fig 4

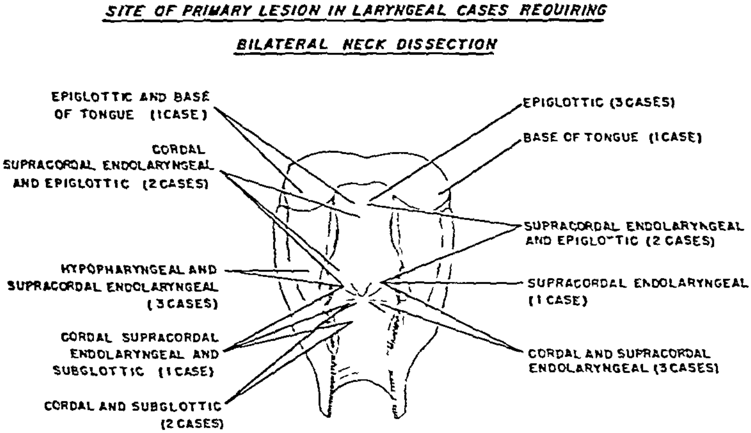
SITE OF PRIMARY LESION IN LARYNGEAL CASES REQUIRING BILATERAL NECK DISSECTION
EPIGLOTTIC AND BASE OF TONGUE (1 CASE)
CORDAL SUPRACORDAL ENDOLARYNGEAL AND EPIGLOTTIC (2 CASES)
HYPOPHARYNGEAL AND SUPRACORDAL ENDOLARYNGEAL (3 CASES)
CORDAL SUPRACORDAL ENDOLARYNGEAL AND SUBGLOTTIC (1 CASE)
CORDAL AND SUBGLOTTIC (2 CASES)
EPIGLOTTIC (3 CASES)
BASE OF TONGUE (1 CASE)
SUPRACORDAL ENDOLARYNGEAL AND EPIGLOTTIC (2 CASES)
SUPRACORDAL ENDOLARYNGEAL (1 CASE)
CORDAL AND SUPRACORDAL ENDOLARYNGEAL (3 CASES)

Fig 5

designations as well as the total laryngeal and hypopharyngeal classification to make our material as valuable as possible to future observers when perhaps a generally accepted classification for these lesions is adopted

Fig 5 shows the site of the primary lesion in 23 cases of bilateral radical neck dissection

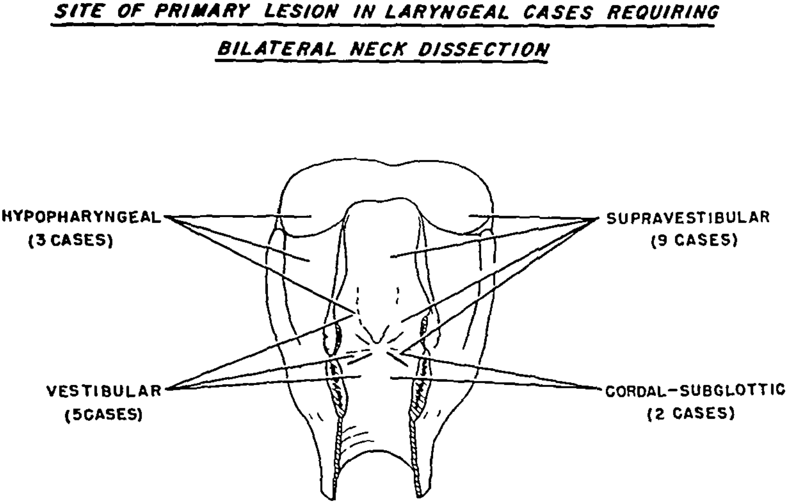
SITE OF PRIMARY LESION IN LARYNGEAL CASES REQUIRING BILATERAL NECK DISSECTION
HYPOPHARYNGEAL (3 CASES)
SUPRAVESTIBULAR (9 CASES)
VESTIBULAR (5CASES)
CORDAL-SUBGLOTTIC (2 CASES)

Fig 6

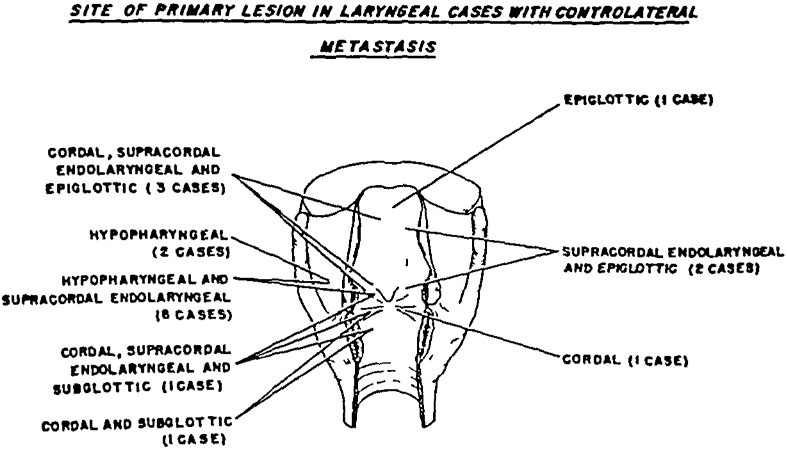
SITE OF PRIMARY LESION IN LARYNGEAL CASES WITH CONTROLATERAL METASTASIS
EPIGLOTTIC (1 CASE)
CORDAL, SUPRACORDAL ENDOLARYNGEAL AND EPIGLOTTIC (3 CASES)
HYPOPHARYNGEAL (2 CASES)
HYPOPHARYNGEAL AND SUPRACORDAL ENDOLARYNGEAL (8 CASES)
SUPRACORDAL ENDOLARYNGEAL AND EPIGLOTTIC (2 CASES)
CORDAL, SUPRACORDAL ENDOLARYNGEAL AND SUBGLOTTIC (1 CASE)
CORDAL (1 CASE)
CORDAL AND SUBGLOTTIC (1 CASE)

Fig 7

Fig 6 demonstrates that the incidence of bilateral metastasis of cordal-subglottic lesions was 10 per cent, of vestibular lesions, 16 per cent, of supra-vestibular lesions 15 per cent, and of hypopharyngeal lesions 5 per cent From these data we conclude that bilaterality of metastases does not appear to be influenced by the site of the primary lesion

While considering bilateral metastasis, we also tabulated the number of cases of contralateral metastasis which did not first have an ipsilateral metastasis We found that contralateral primary metastasis occurred in 17 cases or 9 per cent of the laryngeal and hypopharyngeal cases Figs 7 and 8 demonstrate the site of the primary lesion in these cases of contralateral metastases It will be seen that 47 per cent, or nearly one-half of these cases involved the hypopharynx, and that 35 per cent involved the supravestibular area with involvement of the epiglottis in each case Contralateral metastasis was rare from lesions within the lumen of the larynx

SITE OF PRIMARY LESION IN LARYNGEAL CASES WITH CONTRALATERAL METASTASIS

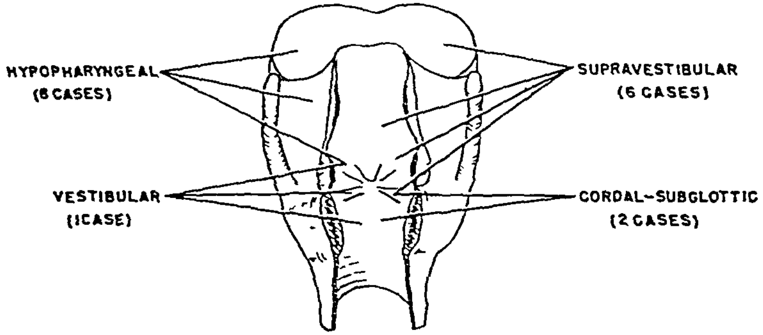

Fig 8

While gathering information on the total sample, we thought it would be of interest to present our findings regarding extra laryngeal involvement in those patients on whom laryngectomy was performed and on whom we had careful studies of the laryngeal specimen This group consisted of 153 carefully dissected larynges The pre-cricoid or cricoid-thyroid node was identified in 39 cases and found positive in seven, or 18 per cent of these cases It appears that in the process of laryngectomy it would be well to avoid dissection of this area of the larynx, and if the larynx is removed from below upward, the operator should be careful not to allow a tenaculum to penetrate the region of the cricoid-thyroid node, else the metastatic tumor cells in this node might be disseminated into the field We found that the pre-epiglottic space showed evidence of tumor extension in 24 cases, or 16 per cent This fact would certainly bear out the necessity of removing the entire hyoid bone during laryngectomy, or at least that portion of the medial section of the hyoid bone forming the anterior limits of the pre-epiglottic space Extension to involve the ala of the thyroid cartilage was found in 17 cases, or 11 per cent, and the strap muscles were found to be positive in eight cases, or 5 per cent These data would certainly appear to substantiate the necessity for "wide field laryngectomy" with removal of the strap muscles during routine laryngectomy The thyroid gland showed evidence of involvement in 3 per cent of the cases, but was removed in only 27 cases In these 27 cases, however, the gland was involved in 13 per cent which would seem to indicate that during the course of laryngectomy or of laryngectomy and radical neck dissection, if there is suspicion of the gland's being involved, it definitely should be removed *en bloc* with the larynx and neck specimen

TABLE III

Pathological Diagnosis of Primary Lesion

Squamous Cell Carcinoma, Grade I	27	60 Low Grade
Squamous Cell Carcinoma, Grade II	33	
Squamous Cell Carcinoma Grade III	117	149 High Grade
Squamous Cell Carcinoma, Grade IV	19	
Undifferentiated Carcinoma	13	
Other	14	
Total	223	

Table III demonstrates the pathological diagnosis in the total group of 223 neck dissections From Fig 9 it will be seen that there were over twice as many relatively high grade lesions as there were low grade lesions

Table IV depicts the treatment of the primary lesion This Table is presented for descriptive purposes only We did not feel that it was the province of this presentation to enter

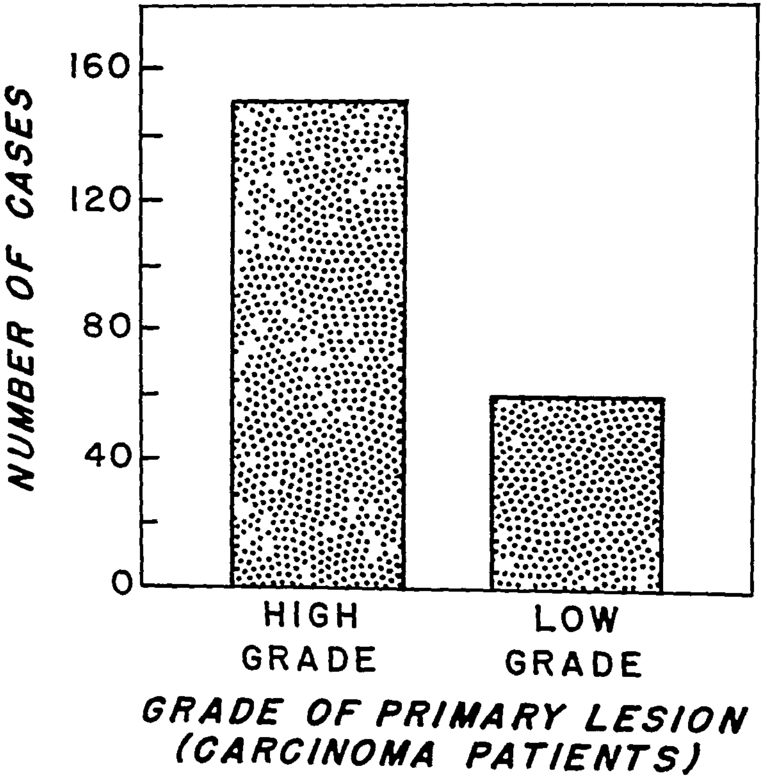

Fig 9

TABLE IV

Type of Treatment of Primary Lesion

Type of Treatment	Number
External Radiation	16
Radium	1
Hemiglossectomy	1
Hemiglossectomy and Laryngectomy	2
Combined Hemiglossectomy and Neck Dissection	5
Hemiglossectomy Laryngectomy and Neck Dissection	2
Commando	2
Laryngo fissure	3
Laryngo fissure and Laryngectomy	2
Laryngectomy	72
Combined Laryngectomy and Neck Dissection	70
Laryngectomy and External Radiation	11
Other Surgical Excisions	12
None	1
Total	200

upward, the operator should be careful not to allow a tenaculum to penetrate the region of the cricoid-thyroid node, else the metastatic tumor cells in this node might be disseminated into the field. We found that the pre-epiglottic space showed evidence of tumor extension in 24 cases, or 16 per cent. This fact would certainly bear out the necessity of removing the entire hyoid bone during laryngectomy, or at least that portion of the medial section of the hyoid bone forming the anterior limits of the pre-epiglottic space. Extension to involve the ala of the thyroid cartilage was found in 17 cases, or 11 per cent, and the strap muscles were found to be positive in eight cases, or 5 per cent. These data would certainly appear to substantiate the necessity for "wide field laryngectomy" with removal of the strap muscles during routine laryngectomy. The thyroid gland showed evidence of involvement in 3 per cent of the cases, but was removed in only 27 cases. In these 27 cases, however, the gland was involved in 13 per cent, which would seem to indicate that during the course of laryngectomy or of laryngectomy and radical neck dissection, if there is suspicion of the gland's being involved, it definitely should be removed *en bloc* with the larynx and neck specimen.

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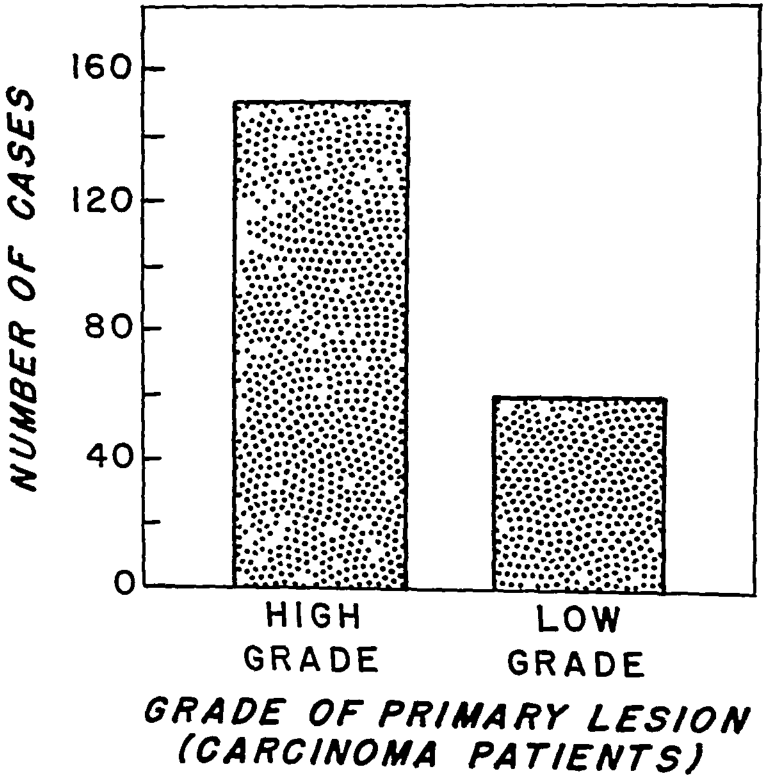

Fig 9

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Laryngo fissure and Laryngectomy	2
Laryngectomy	72
Combined Laryngectomy and Neck Dissection	70
Laryngectomy and External Radiation	11
Other Surgical Excisions	12
None	1
Total	200

into a discussion or presentation of findings regarding the relative merit of radiation, surgery of the primary alone, or surgery of the primary in combination with neck dissection, or surgery plus radiation Therapy would indeed constitute a formidable presentation by itself which we hope to compile in the future It is interesting to note, however, that the number of laryngectomies alone and of combined laryngectomy and neck dissection are essentially equal During the time that these operations were performed relatively few prophylactic neck dissections were being performed at the Massachusetts Eye and Ear Infirmary, therefore, this data indicates the large number of cases in which palpable neck nodes are present at the time the need for laryngectomy is recognized

TABLE V

Time Between Onset of Symptoms and Treatment of Primary Lesion

Time in Months	No of Cases
0-1	10
1-2	27
2-3	27
3-4	21
4-5	22
5-6	18
6-7	8
7-8	4
8-9	6
9-10	0
10-11	2
11-12	16
Over a Year	30
No Information	9

Table V and Fig 10 depict the time intervals between the onset of the patient's symptoms and the treatment of the primary lesion Only 65 per cent of these patients were treated within six months of the onset of symptoms, and 23 per cent did not receive therapy for the primary lesion until 11 months or more after the onset of symptoms The Table again demonstrates the disease's insidious nature, the patient's fear in seeking treatment, and perhaps on occasion the physician's lack of alertness in detecting early cancer

Table VI and Fig 11 are very interesting and clinically

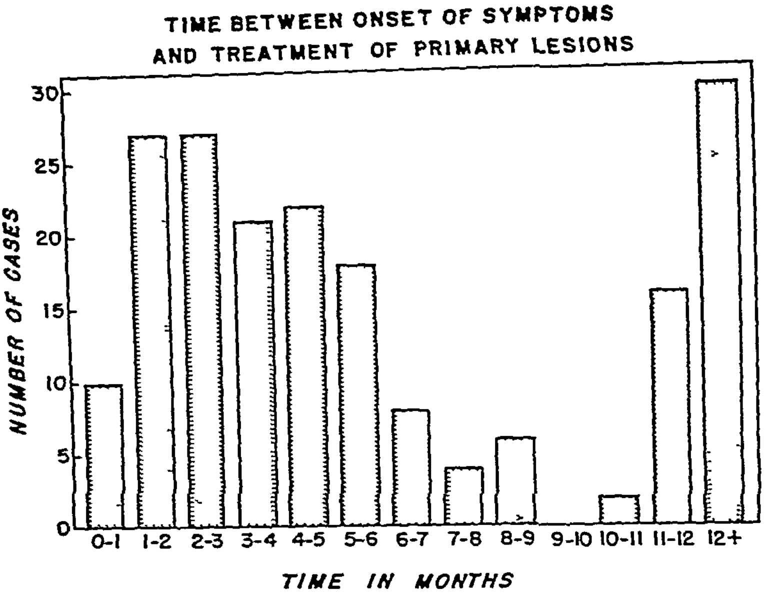

Fig 10

TABLE VI

Time Between Treatment of Primary Lesion and Detection of Metastasis

1-2 Months	29	52%	75%	89%
2-4 Months	16			
4-6 Months	22			
6-8 Months	10	23%		
8-10 Months	5			
10-12 Months	13			
1-2 Years	18	14%		
2 Years	15	11%		

applicable They demonstrate the time elapsed between treatment of the primary lesion and detection of metastasis in those cases in which neck dissection was not done in combination with treatment of the primary lesion It will be seen that the metastasis in over half of the cases was detected within six months of treatment of the primary, 75 per cent within one year, and almost 90 per cent within two years Only 10 per cent metastasized after two years, and 4 per cent between two and five years

Table VII compares the preoperative clinical estimate of

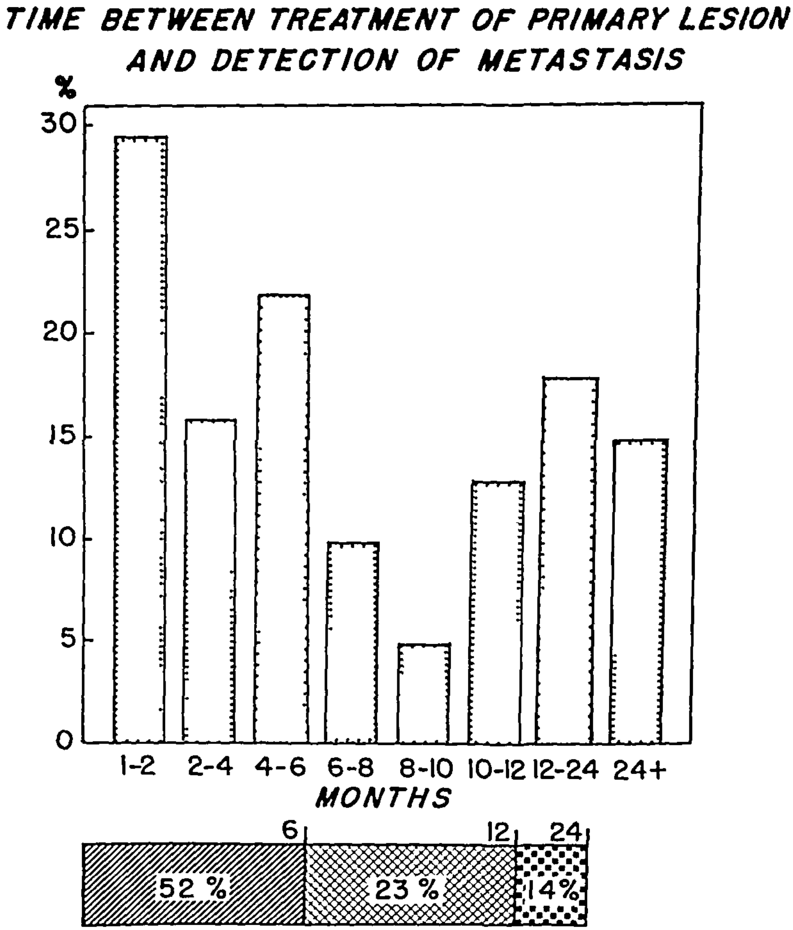

Fig 11

the metastasis with the actual size of the largest metastasis found in the laboratory dissection of the specimen In 93 patients there was available a definite preoperative estimate of the metastasis The preoperative estimate was correct in only 28 per cent of the cases, however, the estimate was within 1 cm one way or the other in 72 per cent of the cases When estimated incorrectly, the estimated size was smaller than the actual size in 35 per cent of the cases, and larger than the actual size in 65 per cent of the cases More encouraging to the clinician performing a palpation of the neck,

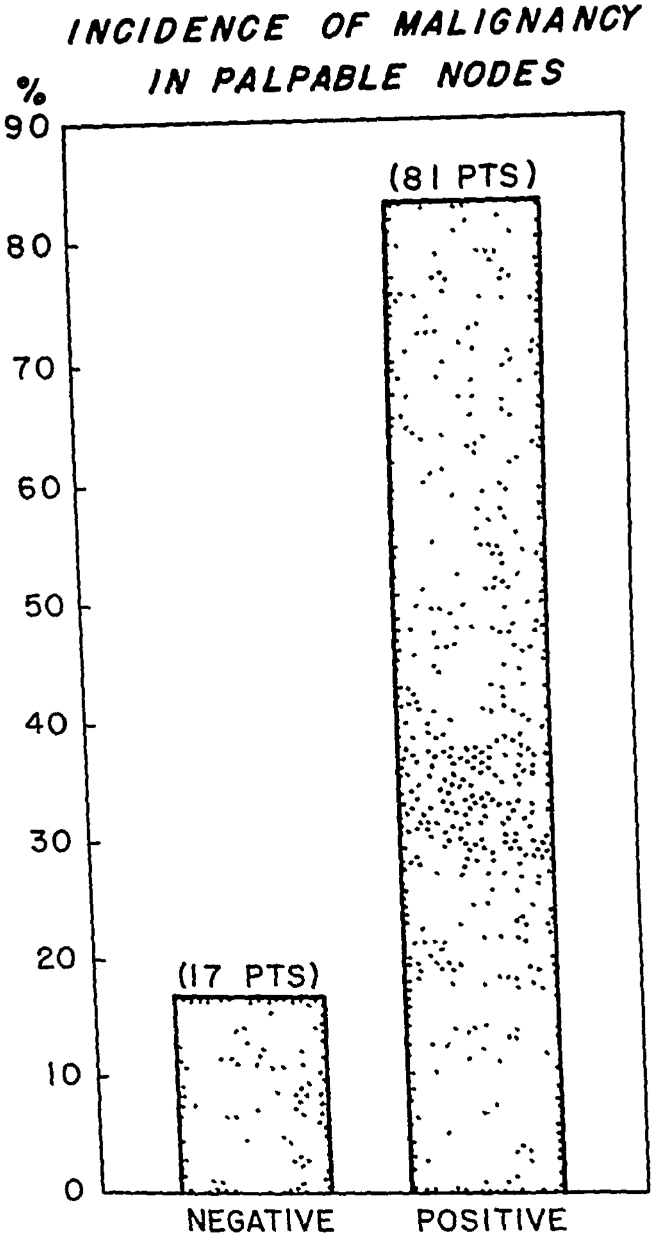
INCIDENCE OF MALIGNANCY IN PALPABLE NODES
%
90
80
70
60
50
40
30
20
10
0
(81 PTS)
(17 PTS)
NEGATIVE
POSITIVE

Fig 12

however, was the finding regarding pathologic evidence of metastasis in clinically palpated nodes As shown in Fig 12 we found the preoperatively palpated nodes showed metastasis in 83 per cent of the cases, and the clinician was in error in only 17 per cent of the cases The reliability of palpation of the neck as to presence or absence of metastasic tumor is a very important point regarding the whole matter of biopsying suspicious or questionable cervical metastasis in cases who have had a known primary malignancy in the head and neck One of us (G F R) in a previous publication[7] expressed vigorous opposition to the practice of biopsying cervical nodes in view of the great potential danger of dissemination of cancer cells and urged the clinician to have the courage of his convictions and to proceed with radical neck dissection rather than precede this procedure by biopsy The above findings would indicate that if a node is palpable there is only a 17 per cent chance of its being negative in the presence of a previous or concomitant primary lesion, and this relatively small chance does not justify the potential dissemination and spread of tumor cells by biopsy If in doubt, and a biopsy is to be considered, it should be in the form of a frozen section biopsy with all preparation made for a performance of a definitive radical neck dissection

TABLE VII

Comparison of Estimate and Actual Size of Nodes

Actual Size	Estimated Size				
	4 cm	3 cm	2 cm	1 cm	Total
4 cm	8	8	10	4	30
3 cm	5	2	9	5	21
2 cm	3	5	6	7	21
1 cm or less	1	5	4	11	21
Total	17	20	29	27	93

EFFECT OF THE DEGREE OF MALIGNANCY ON METASTASIS

After making the above general observations, we turned our attention to the effect of the pathological diagnosis of the primary lesion upon the various factors concerning cervical metastasis

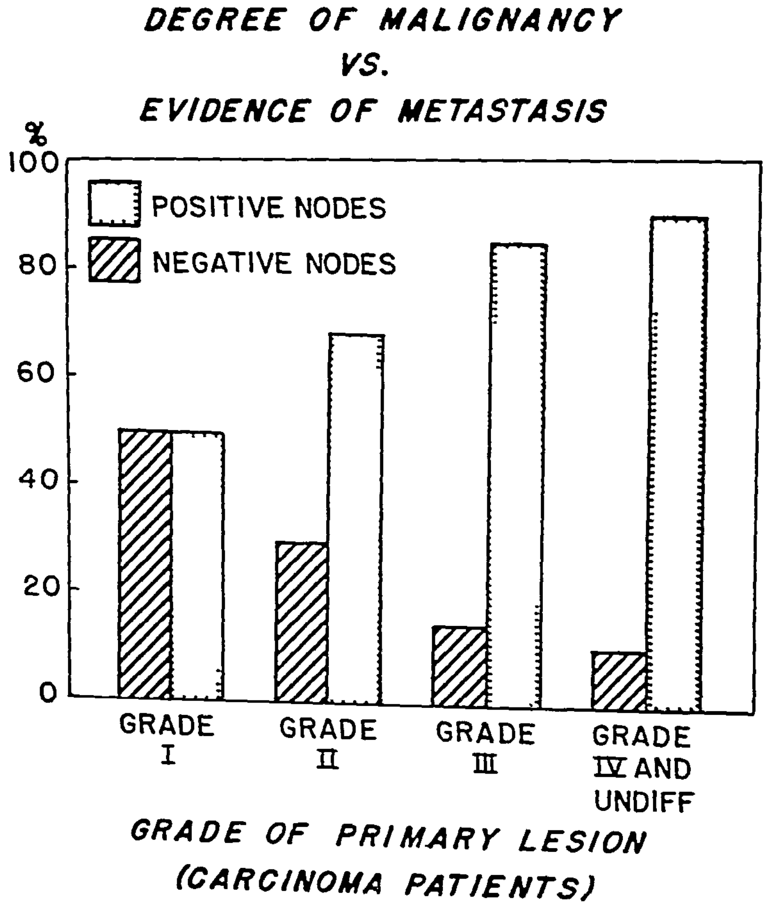

Fig 13

Correlation was made between the pathological diagnosis of the primary lesion and the location of the metastasis This correlation was made in 99 cases in which the metastases were solitary or limited to one area A study of these findings indicated that there was no apparent relationship between the pathological diagnosis or degree of malignancy of the primary lesion and the location of the metastasis

We next studied the effect of the pathological diagnosis of the primary lesion upon the presence of metastasis and the maximum size of the metastatic nodes It will be seen from

Table VIII and Fig 13 that in patients in whom the primary lesion was a Grade I carcinoma, there was a 50 per cent chance of there being no evidence of metastasis in the radical neck specimen In those with Grade II primary lesion there was a 33 per cent chance of there being no evidence of metastasis In those with a Grade II primary lesion there was a 33 per cent chance of there being no evidence of metastasis In those

TABLE VIII

Correlation of Degree of Malignancy with Evidence of Metastasis

Pathological Diagnosis of Primary	Maximum Size of Node				
	4 cm	3 cm	2 cm or Less	No Evidence of Metastasis	Total
Grade I	5	3	6	14	28
Grade II	4	4	13	10	30
Grade III	24	32	30	15	101
Grade IV	7	5	3	2	17
Undifferentiated	5	2	2	1	10
Other	7	4	2	1	14
Total	52	50	55	43	200

TABLE IX

Comparison of the Degree of Malignancy with the Number of Positive Nodes

Grade of Primary Carcinoma	Number of Positive Nodes								
	Solitary	2	3	4	5	6	7	8	9	Total
I and II	20	5	1	0	4	3	1	0	1	36
III	58	13	10	7	3	3	1	0	5	100
IV and Undifferentiated	15	2	4	1	0	1	0	2	3	28

showing a primary lesion of Grade III or more, there was only an 11-15 per cent chance of there being no evidence of metastasis Thus, it would appear that the greater the degree of malignancy of the primary lesion the more likely it is that dissectible cervical nodes will be positively involved We could show no apparent relationship between the degree of malignancy of the primary lesion and the maximum size of the largest metastastic node

We next studied the effect of the degree of malignancy of the primary lesion upon the total number of metastic nodes or multiplicity of metastases Table IX indicates that the degree of malignancy has no significant effect on multiplicity of metastases

It appeared to us that another important relationship to be studied would be that between the degree of malignancy of the primary lesion and the time between the treatment of the primary lesion and detection of metastasis Such a relationship might help us in determining the amount of diligence and frequency required in the postoperative observation following treatment of a primary lesion Much to our surprise, as shown in Table X, there appeared to be no relation between the pathological diagnosis of the primary lesion and the time between the treatment of the primary and detection of the metastasis These findings, of course, do not prove by any means that there is no relation between these two factors, because so many other factors were concerned in these patients such as the follow-up interval, the obesity of the patient, etc , nevertheless, we could not demonstrate a definite relationship between these two factors.

TABLE X

Effect of Degrees of Malignancy on Time of Subsequent Metastasis in Delayed Cases

Time Between Treatment of Primary and Detection of Metastasis	Pathological Diagnosis of Primary						
	Grade I	Grade II	Grade III	Grade IV	Undifferentiated	Other	Total
<1-2 Months	4	1	13	4	3	4	29
2-4 Months	4	1	8	2		1	16
4-6 Months		5	15	2			22
6-8 Months		4	5		1		10
8-10 Months		1	2		1	1	5
10-12 Months	2	2	6	2		1	13
1-2 Years	2	1	10	2	2	1	18
>2 Years		5	7	2		1	15
Total	12	20	66	14	7	9	128

EFFECT OF SITE OF THE PRIMARY LESION

In order to determine the possible effects and influences of the site of the primary lesion, various correlations were

TABLE XI

Comparison of Site of Primary Lesion with Presence and Multiplicity of Metastases

Site of Primary	No Evidence Metastasis	Solitary Metastasis	Multiple Metastasis	Total		No Evidence Metastasis	Solitary Metastasis	Multiple Metastasis
Cordal Subglottic Area								
Group A	4	5	0	9	24	6	13	5
Group B	0	1	0	1				
Group C	2	7	5	14				
Vestibular Area								
Group D	1	2	4	7	35	8	12	15
Group E	4	9	8	21				
Group F	3	1	3	7				
Supravestibular Area								
Group G	2	10	3	15	69	13	39	17
Group H	7	5	2	14				
Group I	3	11	7	21				
Group J	1	8	2	12				
Group K	0	5	2	7				
Hypopharyngeal Area								
Group L	4	6	8	18	67	14	27	26
Group M	0	1	2	3				
Group N	10	20	16	46				
Other Laryngeal	3	3	4	10				
Non Laryngeal	4	5	9	18				
Total	48	99	76	223				

TABLE XII
Effect of Primary Site on Maximum Size of Nodes

	Maximum Size of Nodes									
Site of Primary	4 cm	3 cm	2 cm or less	No Evidence Malignancy	Total		4 cm	3 cm	2 cm or less	No Evidence Malignancy
Cordal Subglottic Area										
Group A	2		3	4	9					
Group B			1		1	21	3	5	8	5
Group C	1	5	4	1	11					
Vestibular Area										
Group D	4	2			6					
Group E	8	3	3	4	18	31	14	7	3	7
Group F	2	2		3	7					
Supravestibular Area										
Group G	3	6	2	1	12					
Group H	1	1	4	7	13					
Group I	6	6	4	3	19	61	16	18	15	12
Group J	4	3	2	1	10					
—Group K	2	2	3		7					
Hypopharyngeal Area										
Group L	4	3	7	4	18					
Group M	1	1	1		3	63	13	16	21	13
Group N	8	12	13	9	42					
Other Laryngeal	2		3	3	8					
Non Laryngeal	4	4	5	3	16					
Total	52	50	55	43	200					

TABLE XIII

Number and Location of Nodes by Site of Primary Lesion

Site of Primary	Location and Number of Metastatic Nodes																			
	Upper Jugular	Middle Jugular	Lower Jugular	Submaxillary	Supraclavicular	Submental	Accessory	No Evidence Malignancy	Total Nodes		Upper Jugular	Middle Jugular	Lower Jugular	Submaxillary	Supraclavicular	Submental	Accessory	No Evidence Malignancy	Total Nodes	Total Cases	Nodes per Case
Cordal Subglottic Area																					
Group A	2	1	1		2			4	6	29	16	6	3	1	3			6	29	21	= 1 4
Group B					1				1												
Group C	14	5	2	1				2	22												
Vestibular Area																					
Group D	8	3	4	3				1	18	91	38	14	22	11			6	8	91	31	= 2 9
Group E	24	7	12	8			3	4	54												
Group F	6	1	6				3	3	19												
Supravestibular Area																					
Group G	14	3	7	9		1		2	34	139	59	22	32	23		1	2	13	139	61	= 2 3
Group H	5	3	3	2				7	13												
Group I	23	11	16				2	3	52												
Group J	8	3	5	3				1	19												
Group K	9	2	1	9					21												
Hypopharyngeal Area																					
Group L	17	9	11		2		1	4	40	138	67	34	20	5	11		1	14	138	63	= 2 2
Group M	6	1	1						8												
Group N	44	24	8	5	9			10	90												
Other	9	3	3	1				7	16		9	3	3	1				7			
Total ..	189	79	80	41	14	1	9	48	413												

made Comparison of the site of the primary lesion with the presence of metastasis in Table XI showed that the site of the primary lesion appeared to have no effect on whether palpable nodes contained malignant cells

We also studied the relationship between the primary site and the maximum size of positive nodes and could demonstrate no relationship between these two factors These findings are shown in Table XII

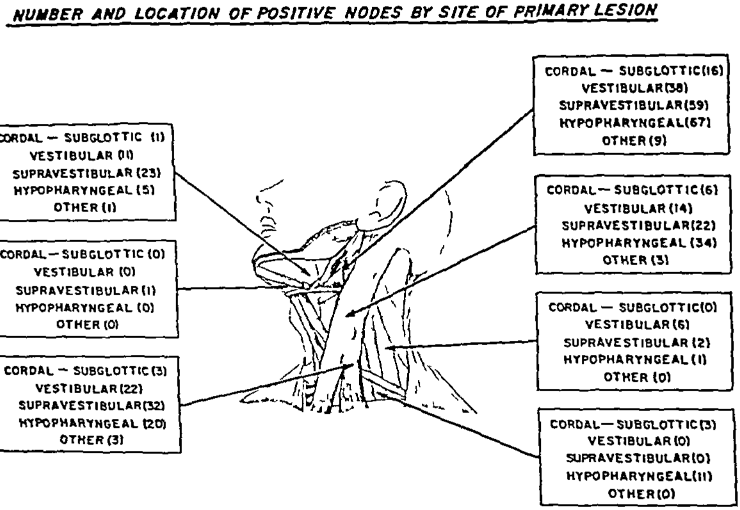
NUMBER AND LOCATION OF POSITIVE NODES BY SITE OF PRIMARY LESION
CORDAL — SUBGLOTTIC (1) VESTIBULAR (11) SUPRAVESTIBULAR (23) HYPOPHARYNGEAL (5) OTHER (1)
CORDAL—SUBGLOTTIC (0) VESTIBULAR (0) SUPRAVESTIBULAR (1) HYPOPHARYNGEAL (0) OTHER (0)
CORDAL — SUBGLOTTIC (3) VESTIBULAR (22) SUPRAVESTIBULAR (32) HYPOPHARYNGEAL (20) OTHER (3)
CORDAL — SUBGLOTTIC (16) VESTIBULAR (38) SUPRAVESTIBULAR (59) HYPOPHARYNGEAL (67) OTHER (9)
CORDAL—SUBGLOTTIC (6) VESTIBULAR (14) SUPRAVESTIBULAR (22) HYPOPHARYNGEAL (34) OTHER (3)
CORDAL — SUBGLOTTIC (0) VESTIBULAR (6) SUPRAVESTIBULAR (2) HYPOPHARYNGEAL (1) OTHER (0)
CORDAL—SUBGLOTTIC (3) VESTIBULAR (0) SUPRAVESTIBULAR (0) HYPOPHARYNGEAL (11) OTHER (0)

Fig 14

Comparison of the effect of the primary site upon the number and location of nodes is presented in Table XIII and Fig 14 Table XIII is rather complex it demonstrates the location of positive nodes and gives the sites of the primary lesion in detail so that the reader may make his own compilations and conclusions In general, cordal-subglottic lesions appeared to have fewer nodes per case than did those of other sites, and vestibular lesions had the most nodes per case, ranking ahead of supravestibular and hypopharyngeal lesions in that order Although the distribution of nodes to the upper jugular and middle jugular chains was fairly uniform throughout the various primary sites, there appeared to be a higher incidence of involvement of the middle jugular nodes in hypopharyngeal lesions Extension to involve the lower jugular nodes was fairly evenly distributed with somewhat less tendency of the cordal-subglottic lesions to metastasize to this area It is interesting to note that the supravestibular lesions accounted for a much higher percentage of the cases showing submaxillary involvement than the other groups, while the hypopharyngeal lesions were responsible for most of the metastases to the supraclavicular nodes Vestibular lesions accounted for two-thirds of the nodes involving the region of the spinal accessory nerve In only one case was metastasis found in the submental region

Occasionally the question is raised of the feasibility of doing somewhat less than what is now considered a total radical neck dissection, and Table XIII would indicate that there is sufficient involvement of the various areas encompassed by the presently accepted neck dissection in these 200 cases to make a total dissection mandatory whenever neck dissection is considered at all

Table XIV reveals that there is no correlation between the site and grade of the primary lesion, therefore, it appears that the site of the primary influences the number of positive nodes per case independently of grading

INFLUENCE OF THE SIZE AND LOCATION OF PRIMARY NODE ON SUBSEQUENT NODES

We next turned our attention to a study of the influence of the primary metastatic node on subsequent or satellite nodes In this regard we considered the largest node in the specimen to be the primary node, and in almost all cases we found that there was one node or group of nodes which constituted the main metastatic mass with scattered smaller or satellite nodes We noted with interest that, of 99 cases where the metastasis clinically appeared as a solitary mass in 31 cases or 31 per cent, it was found on dissection to be a group of nodes in one place rather than a single node A study of the influence of the size of the primary node on the total number of positive nodes is presented in Table XV It will be seen that nodes 4 cm or larger were found in 76 neck specimens, and in 47

TABLE XIV

Comparison of Pathological Diagnosis of Primary and Site of Primary Lesion

									Pathological Diagnosis of Primary Lesion					
	Grade								Grade					
Site of Primary	I	II	III	IV	Undifferentiated	Other	Total		1	II	III	IV	Undifferentiated	Other
Cordal Subglottic Area								21	4	2	12	2	1	
Group A	3		3	2	1		9							
Group B			1				1							
Group C	1	2	8				11							
Vestibular Area								31	4	7	14	3	1	2
Group D		1	3	1	1		6							
Group E	4	3	8	1		2	18							
Group F		3	3	1			7							
Supravestibular Area								61	6	6	37	5	3	4
Group G	1	2	8			1	12							
Group H	3		6	1	2	1	13							
Group I	2	2	11	3		1	19							
Group J			10				10							
Group K		2	2	1	1	1	7							
Hypopharyngeal Area								63	10	10	32	4	2	5
Group L	3	2	8	1	2	2	18							
Group M	1		2				3							
Group N	6	8	22	3		3	42							
Other Laryngeal	2	1	4	1			8							
Non Laryngeal	2	4	2	2	3	3	16							
Total	28	30	101	17	10	14	200		24	25	95	14	7	11

per cent of these there was a solitary metastasis, whereas in 53 per cent there were multiple metastases Three cm nodes were found in 40 necks, and in 52 5 per cent of these there was a solitary metastasis, and in 47 5 per cent there were multiple metastases Nodes measuring 2 cm or less were found in 59 specimens, and in 71 per cent of these there was a solitary metastasis, and in only 29 per cent were there multiple metastases We feel from these findings and Table XV that the number of positive nodes and the tendency to multiple metastases increases in proportion to the size of the primary metastatic node

TABLE XV

Influence of Size of Primary Node on Total Number of Positive Nodes

Size of Primary Node	Number of Nodes									
	Solitary Metastasis	2	3	4	5	6	7	8	9 or over	Total
4 cm	36	4	7	6	7	7	1	2	6	76
3 cm	31	6	4	3	2	1			3	40
2 cm or less	42	9	2	1	2	2			1	59
Total	99	19	13	10	11	10	1	2	10	175

TABLE XVI

Correlation of Size of Primary Node and Number of Metastatic Areas Involved

Size of Primary Node	Number of Areas Involved in Metastasis 1	2	3	4	Total
4 cm	36	23	12	5	76
3 cm	21	11	7	1	40
2 cm or smaller	42	13	4		59
Total	99	47	23	6	175

We next studied the influence of the size of the primary node on the total number of areas involved in metastasis and these findings are presented in Table XVI These findings indicate that the number of areas involved is in proportion to the size of the primary node This relationship is in accord with the previous finding of a correlation between multiple metastases and size of the primary node

We then made a tabulation of the influence of the site of the primary node upon the location of subsequent nodes This material is presented in Fig 15 It is interesting to note that, if the primary node is in the upper jugular region, the secondary node will be in the middle jugular region 53 per cent of the time and in the lower jugular area 33 per cent of the time This finding conforms with the usual thinking regarding spread of subsequent metastasis We found, however, that

LOCATION OF 2° NODE AS RELATED TO 1° NODE LOCATION

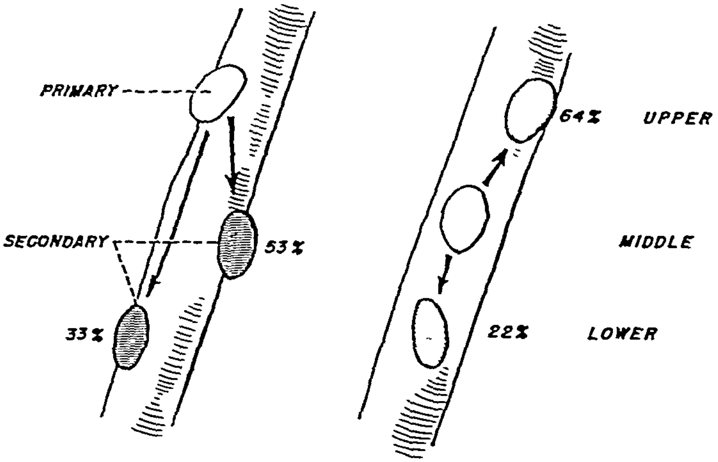

Fig 15

if the primary node is in the middle jugular area, the secondary node will occur in the upper jugular region 64 per cent of the time and in the lower jugular region only 22 per cent of the time

SURVIVAL DATA

Unfortunately, in this study we found that we did not have sufficient patients of potential four and five year survival to be of significance Although we had numerous potential two year survivors, we did not feel that two years was a sufficiently long follow-up period and decided to base our survival statistics on 84 patients whose neck dissection had been performed three or more years prior to this study, and thus, were potential three year survivors

Table XVII demonstrates the overall survival figures There are 21 cases (or 25 per cent) living with no evidence of recurrence three years or more after their radical neck dissection, however, 13 of these 21 had shown no evidence of malignancy on dissection of their neck specimens Only eight, or 17 per cent of those patients whose neck specimens showed positive nodes have survived three years Of the 23 patients on whom bilateral neck dissections were performed, there were ten potential three year survivors Four of these patients were living without evidence of recurrence three years after operation, five were dead of disease, and one had died of other causes Five were living with no evidence of recurrence more than a year after surgery, and three more than two years after surgery Three patients had died of disease less than a year following operation, and one died of disease less than two years following surgery One patient of these 23 was lost to follow-up There were four patients with bilateral neck dissections on whom there was no evidence of metastases on one side upon pathologic examination Two of these patients are living without recurrence four years after surgery, and one two years after surgery One was living with recurrence three years after surgery

TABLE XVII

Overall Survival Data

Living—No Evidence of Recurrence	21	25%
Living with Recurrence	5	6%
Dead of Disease	46	55%
Dead of Other Causes	6	7%
Lost to Follow up	6	7%
Total	84	

Following a fairly systematic plan of comparing survival figures against the data available from this study, we compared the three year follow-up data according to the site of the primary lesion The results of these compilations are presented in Table XVIII and Fig 16 which present a number

TABLE XVIII

Survival According to Site of Primary Lesion

Site of Primary Lesion	Living No Evidence Recurrence	Living with Recurrence	Dead of Disease	Dead Other Causes	Lost to Follow-up	Total		Living No Evidence Recurrence	Living with Recurrence	Dead of Disease	Dead Other Causes	Lost to Follow-up
Cordal and Subglottic Area												
Group A	2		2	1		5	10	4 (10%)		4 (40%)	1	1
Group B					1	1						
Group C	2		2			4						
Vestibular Area												
Group D		2	1			3	18	7 (39%)	4	5 (28%)		
Group E	6	1	1		2	10						
Group F	1	1	3			5						
Supravestibular Area												
Group G	1		4			5	20	3 (15%)	1	13 (65%)	1	2
Group H	1	1	2	1	2	7						
Group I	1		4			5						
Group J			1			1						
Group K			2			2						
Hypopharyngeal Area												
Group L			1	1		2	22	5 (23%)		13 (59%)	3	1
Group M	1		2			3						
Group N	1		10	2	1	17						
Other Laryngeal	1		4			5						
Non Laryngeal	1		7	1		9						
Totals	21	5	46	6	6	84						

of interesting findings, the most important of which is that the percentage of patients living without recurrence is much higher in the cordal-subglottic and vestibular groups than in supravestibular and hypopharyngeal groups In evaluating the patients who had died of disease within three years, it is seen that the supravestibular lesions account for the greatest percentage of these patients, and would, therefore, appear to carry the worst prognosis

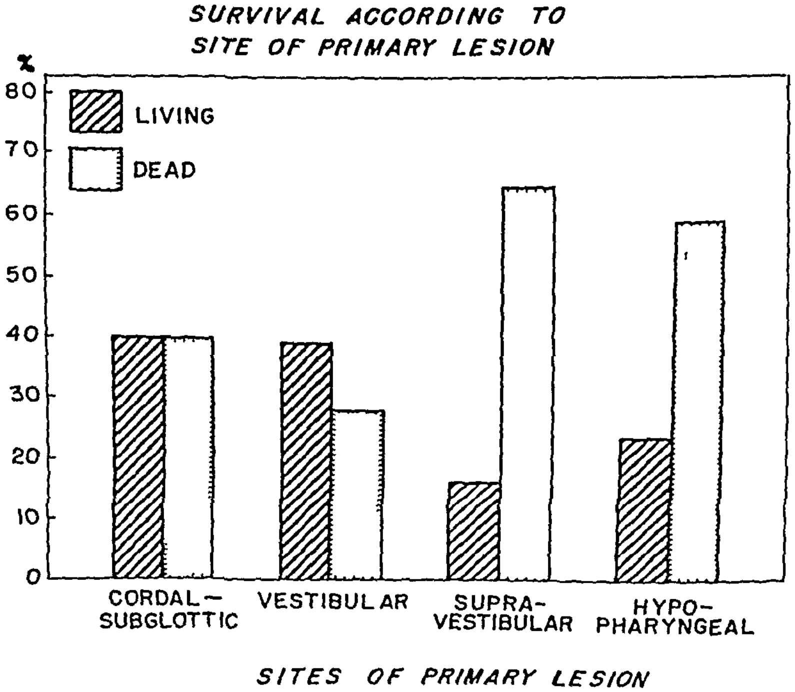

Fig 16

We were pleasantly surprised to find that five of 22 patients in the hypopharyngeal group were living with no evidence of recurrence three years following surgery, and that four of these five constituted large lesions of the pyriform sinus with extension into the endolarynx It is fairly well accepted that lesions which are limited to the endolarynx have a much better prognosis than supravestibular and hypopharyngeal lesions

It is very encouraging, however, to find hypopharyngeal lesions showing a 25 per cent three year survival rate with the use of neck dissection

A study of the effect of location of the primary node upon survival revealed that the location of the primary node does not appear to affect survival

Table XIX demonstrates the effect of the actual size of the primary node upon survival A study of this Table reveals that there appears to be no correlation between the actual size of the primary node and survival This finding was especially surprising and rather dismaying, since one of us (G F R) had previously shown a definite relationship between the size of the primary node and survival in a study based on 75 patients using estimated size of nodes and two year survival[7] In an attempt to reconcile the variation between the findings in Table XIX and our previous findings, we compared the actual size of the node and the estimated size to the two year, three year, four year and five year survival findings in Table XX (We hasten to point out that numbers in Table XX differ from those in Table XIX because Table XX is computed in years while the concise three year survival rates in all other tables were computed in months)

TABLE XIX

Survival According to Actual Size of Primary Node

Site of Primary Node	Living No Evidence of Recurrence	Living with Recurrence	Dead of Disease	Dead of Other Causes	Lost to Follow-up	Total
4 cm	5	4	14	1	2	25
3 cm	3		10	1		14
2 cm or less	3		16	1	4	24
No Evidence of Metastasis	10	1	6	4		21
Total	21	5	46	6	6	84

Although a study of Table XX appears to indicate a slight tendency toward a better prognosis when the estimated size of the node is less than 2 cm , it is certainly not the striking difference we found in our previous study We still feel that such a relationship does exist, since we demonstrate elsewhere

TABLE XX

Survival by Actual and Estimated Size of Node

Primary Node	2 Years or Less		3 Years		4 Years		5 Years		Total
	Living, No Recurrence	Dead	Living, No Recurrence	Dead	Living, No Recurrence	Dead	Living, No Recurrence	Dead	
Actual Size—									
1 cm	15	16	6	2		0	1	1	41
3 cm	17	18	2	1	3	0			41
2 cm or less	14	19	5			0	1	1	40
Total	46	53	13	3	3		2	2	122
Estimated Size—									
1 cm	6	7						1	20
3 cm	9	7		2	1			1	20
2 cm or less	23	19	5		3		2		52
Total	38	33	5	2	4		2	1	85

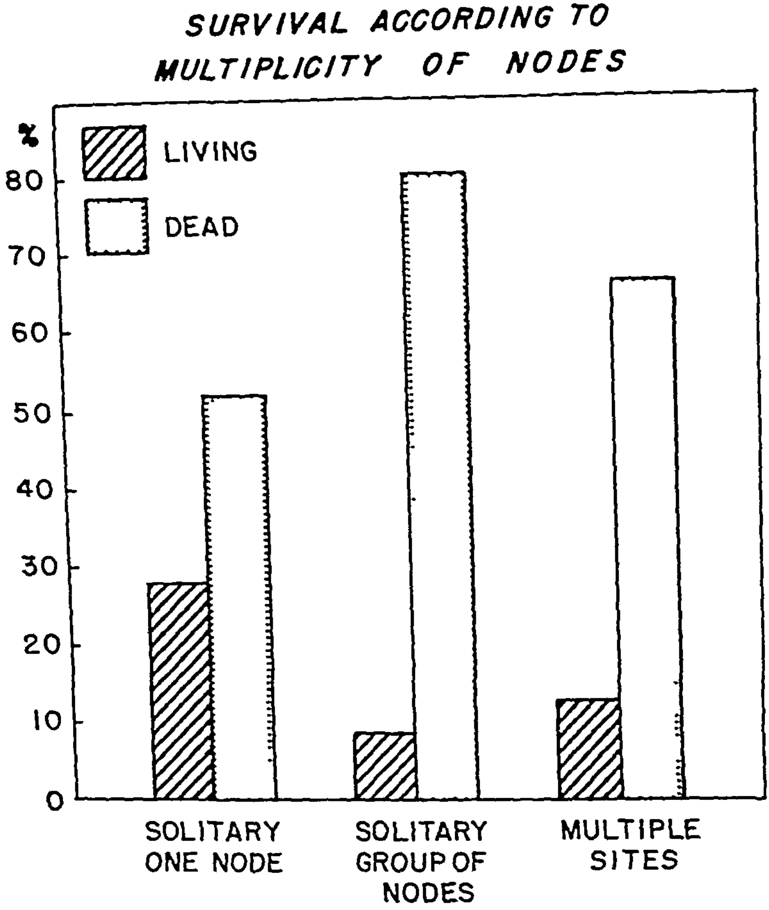

Fig 17

in this paper a direct relationship of node size on the tendency to multiplicity of metastases, total number of nodes and to the number of areas of cervical involvement, each of which in turn appear to affect survival, therefore, we have indirect evidence that survival decreases with node size although we cannot demonstrate it directly as we did in our previous study Clinically, it would certainly appear that the prognosis is much more grave in large metastatic nodes than in smaller ones, and to help resolve this problem we are presently engaged in reappraisal of the original 75 patients

We next studied the survival of these patients with reference to whether the metastasis was a solitary node, a group of nodes in one place, or nodes in more than one area This tabulation shown in Table XXI and Fig 17 reveals some very interesting findings The predominance of patients living with no evidence of recurrence for three years is in the cases in which the metastasis was limited to one node The survival rate of cases with only one node (28 per cent) is more than twice that of cases with more than one node in a single location (7 per cent) This finding is confirmed by the fact that multiple metastases constitute more than twice as many cases dead of disease as does solitary involvement This tendency to a poor prognosis where there are multiple metastases is in agreement with the findings of Taylor and Nathanson[8] It is also in agreement with a "pet theory" of ours that metastatic cancer is contained within the first or primary metastatic node for a fairly long period of time and is more definitely curable until the node reaches a certain size At this time the cancer breaks through the capsule of its node to form a suddenly larger metastatic mass or to produce adjacent satellite nodes Once these changes occur the prognosis drops precipitously These phenomena might also account for the sudden appearance of rather large nodes which we have all seen clinically

TABLE XXI

Survival According to Multiplicity of Nodes

	Living, No Evidence of Recurrence	Living with Recurrence	Dead of Disease	Dead of Other Causes	Lost to Follow-up	Total
Solitary—One Node	7	1	13	1	3	25
Solitary—Group of Nodes	1	0	12	1	1	15
Multiple Metastases	3	3	15	0	2	23
No Evidence of Malignancy	10	1	6	4	0	21

We next wondered, in view of present day difficulties in obtaining hospital beds and operating time, what effect the time between detection of metastasis and definitive surgery would have upon survival of these patients Table XXII in-

TABLE XXII

Survival Based on Time Between Detection of Metastasis and Surgery

Time Between Detection of Metastasis and Surgery	Living No Evidence of Recurrence	Dead of Disease	Other	Total
1 Week	12 (25%)	23 (48%)	13	48
2 Weeks	5 (30%)	8 (61%)		13
3 Weeks		3 (70%)	1	4
4 Weeks	2 (22%)	5 (55%)	2	9
Other			10	10
Total	19	39		84

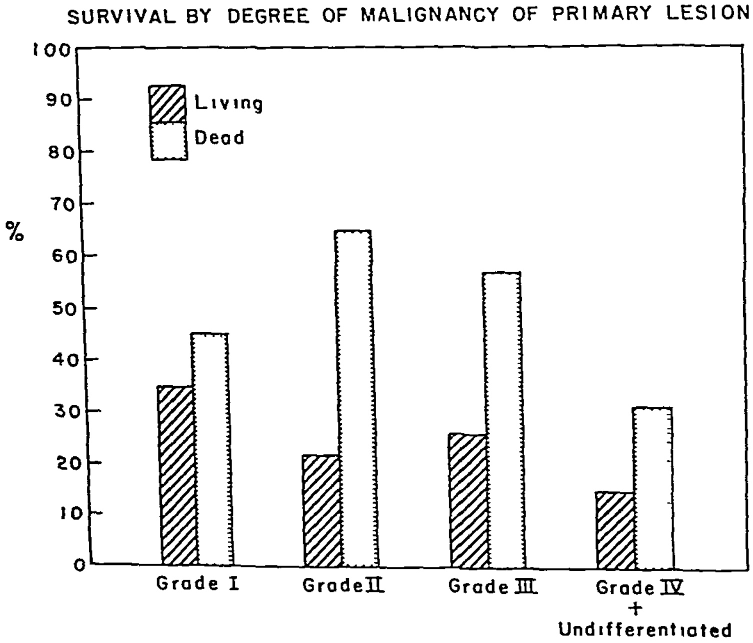

Fig 18

dicates that it makes no apparent difference in the three year survival rate whether the operation is performed one week or as long as four weeks after detection of metastasis

Although the grade of the primary lesion had shown no appreciable effect on metastasis, we wondered whether it would affect survival The results of this correlation are shown in Table XXIII and Fig 18 Although there appears to be a higher percentage of patients living without recurrence in low grade lesions, this relationship is not confirmed in the group dead of disease

DISCUSSION

In the course of this investigation we have come up with a number of positive and negative findings with emphasis on the latter These findings have raised almost as many questions as they have answered We will discuss the more important of our findings and present our conclusions and opinions regarding the answers they have yielded and the questions they have raised

TABLE XXIII

Effect of the Degree of Malignancy of the Primary Lesion on Survival

	Living, No Evidence of Recurrence	Living with Recurrence	Dead of Disease	Dead of Other Causes	Lost to Follow-up	Total
Grade I	7	1	9	0	3	20
Grade II	5	0	15	2	1	23
Grade III	7	1	15	2	1	26
Grade IV and Undifferentiated	2	3	5	2	1	13
Other	0	0	2	0	0	2
Total	21	5	46	6	6	84

Regarding contralateral metastasis, we found that nearly half of the cases involved the hypopharynx, and a third of the cases were of supravestibular origin, involving the epiglottis Contralateral metastasis was rare from lesions within the lumen of the larynx Although based on a relatively small number of cases, these findings might be of value clinically to those who favor prophylactic neck dissection on the contralateral side It would appear from our figures that prophylactic contralateral dissection might be indicated in cases of hypopharyngeal or supravestibular primaries, but would be less justified in lesions arising in the lumen of the endolarynx

The cricothyroid lymph node was positive in 18 per cent of the 39 cases in which it was identified, and accordingly it would appear wise to avoid instrumentation in the region of this node at the time of laryngectomy The ala of the thyroid cartilage was invaded in 17 cases, or 11 per cent Since tumor involved the preepiglottic space in 16 per cent and the strap muscles in 5 per cent of our laryngectomy specimens, it would seem mandatory that a laryngectomy should be of the "wide field" type, including resection of the greater portion of the hyoid bone and the strap muscles to insure removal of the tumor in these sites

Our findings regarding the thyoid gland are of insufficient number to draw conclusions In this series the thyroid gland was removed only when there was suspicion at time of operation that it was involved The specimens showed positive involvement in 13 per cent of those cases in which it was removed Ogura found involvement of the thyroid gland in 10 per cent of his cases[4] Although we have insufficient data on which to draw conclusions, our opinion is that in the course of combined laryngectomy and radical neck dissection it is probably better cancer surgery to excise the thyroid lobe Conversely, in the performance of a total laryngectomy in the absence of suspicion of thyroid gland involvement it should not be excised One lobe can then be removed at the time of subsequent radical neck dissection without difficulties of hypoparathyroidism should metastasis occur

In our laryngectomized patients there was essentially an equal number of combined laryngectomy-neck dissections and laryngectomies alone Since very few prophylactic neck dissections were done during the period of this study, it would appear that there is a high incidence of metastasis at the time primary laryngeal lesions are discovered Only 65 per cent of the patients in this series were treated for their primary lesion within six months of the onset of symptoms, and 23 per cent received therapy eleven months or more after the onset of symptoms

Over one-half of these patients demonstrated cervical metastasis within six months of the treatment of their primary, 75 per cent within a year, and almost 90 per cent within two years In only 10 per cent did metastasis occur after two years We feel that these are very comforting statistics to quote patients who have passed their one and two year post-operative periods

Another interesting finding was the unreliability of the pre-operative estimate of node size We found that the preoperative estimate was correct in only 28 per cent of our cases in which this information was available It is somewhat comforting to the surgeon to know, however, that, when wrong, the estimate was within 1 cm, one way or the other, in 72 per cent of the cases It is also comforting to know that when estimated incorrectly, the estimated size was smaller than actual size in only a third of the cases and larger than actual size in two-thirds of the cases In essence, when estimating node size, the surgeon usually estimates the node larger than it actually is, but he is usually within 1 cm of its actual size

As Taylor and Nathanson[8] have pointed out, "Enlargement or palpability of nodes is the most dependable guide to the presence of metastasis, and the other characteristics of nodes are secondary to it" We were pleased to be able to confirm this point by our finding that palpable cervical nodes in patients with known head and neck primary cancer, show evidence of metastasis 83 per cent of the time In other words, the clinician will be in error only 17 per cent of the time This finding is also quite consistent with the overall error of 16 4 per cent in Kuhn's study[2] As stated earlier, this finding strengthens our previous feeling that biopsy of cervical nodes in patients with known head and neck primary cancer is to be condemned If there are serious doubts regarding the palpable node, a frozen section biopsy should be done with preparation for a definitive radical neck dissection, however, it is preferable to have the courage of one's convictions and proceed with neck dissection, and our findings indicate that it will be proper therapy 83 per cent of the time

Effect of Degree of Malignancy

In this group of 200 patients there were twice as many lesions of relatively high grade malignancy as of low grade, moreover, it appears that the greater the degree of malignancy of the primary lesion, the more likely it is that dissectible nodes will be positive. There was no apparent relationship between the degree of malignancy of the primary lesion and the maximum size of the largest metastatic node, and no apparent relationship between the degree of malignancy of the primary and the tendency to multiple metastases

The pathological diagnosis of the primary lesion had no apparent effect upon the location of the metastasis Since there was a high incidence of high grade malignancy of the primary in this series of patients on whom neck dissection was performed, and since the greater the degree of malignancy the more likely that dissected nodes would be positive, we feel that a patient with a high grade primary lesion should be watched more carefully for cervical metastasis than one with a low grade lesion

Site of Primary Lesion

Variations in the site of the primary lesion had no apparent effect on whether palpable nodes contained malignant cells There was also no apparent effect upon the maximum size of the metastatic nodes Regarding number of nodes, however cordal-subglottic lesions had the least number of nodes per case, vestibular lesions accounted for the greatest number of nodes per case, and supravestibular and hypopharyngeal lesions following in that order

Laryngeal and hypopharyngeal lesions metastasized predominantly to the upper jugular and middle jugular nodes in this series as in others[5] There appeared to be a higher incidence of involvement of the middle jugular nodes in hypopharyngeal lesions Extension to the lower jugular nodes was fairly evenly distributed with somewhat less tendency of the cordal-subglottic lesion to metastasize to this area As might be expected from their locations, supravestibular lesions accounted for the greatest proportion of metastasis to the submaxillary region, and hypopharyngeal lesions were responsible for most of the metastases to supraclavicular nodes Vestibular lesions accounted for two-thirds of the nodes involving the region of the spinal accessory nerve, and in all 223 neck specimens only one positive node was found in the submental region

Site and Location of Primary Node

In studying the metastatic nodes it is of interest to note the location of the secondary node in relation to the position of the first node If the primary node appeared in the upper jugular region, the subsequent nodes were in the middle and lower jugular areas as expected If the primary node was in the middle jugular chain, however, the secondary node was more apt to be in the upper jugular rather than the lower jugular region

In 99 cases in which the metastasis appeared clinically as a solitary mass, it was found by dissection of the specimen to be a group of nodes in one place rather than a single node in 31 cases

We also found that there was a strong tendency for the number of positive nodes to increase as the size of the primary node increased As the size of the primary node increased the number of areas involved in the metastasis also appeared to increas as did the tendency to multiple metastases

Survival

Our findings, based on 84 potential three year survivors, yielded some rather surprising findings The overall survival figures indicated that 25 per cent were living, with no evidence of recurrence three or more years after radical neck dissection This finding fairly well approximates the cure rate reported by others[1,3 5 6], however, when this group of survivors is studied more closely, one is dismayed to find that 13 of the 21 survivors showed no evidence of malignancy on microscopic examination of the neck specimen There were only eight, or 17 per cent, three year survivors in patients in whom the neck specimen showed positive nodes This salvage rate is woefully small when one considers the morbidity connected with this operation

In respect to prognosis, the site of the primary lesion appears to have significance The percentage of patients living with no evidence of recurrence was much higher in those with primary lesions involving the cordal-subglottic and vestibular regions than in those with the primary site involving the supravestibular and hypopharyngeal regions, in fact, the supravestibular lesions accounted for the greatest number of patients dead of disease within three years and thus appear to carry the worst prognosis Patients in whom the primary lesion involved the cordal-subglottic and vestibular regions had better than a fifty-fifty chance of survival As noted before, it is very encouraging to find five three year survivors of 22 patients in whom the primary lesion involved the hypopharyngeal area Most of these patients had large lesions spreading on to the epiglottis and the base of the tongue or over into the endolarynx This finding would appear to aid and abet the recent tendency of attempting a surgical cure of these hypopharyngeal lesions which were previously relegated to palliative X-ray therapy

There appeared to be little difference in the three year figures between the patients living without recurrence and those dead of disease, whether the operation was performed one week after detection of metastasis or four weeks following such detection

In the study of survival of these patients, it was apparent that the more positive nodes there are per case, the lower the survival rate In an analysis of the factors related to the number of positive nodes per case we found two main variables these were the site of the primary lesion, and the maximum size of positive nodes A study of these variables shows that cordal-subglottic lesions tend to have fewer nodes per case, and vestibular lesions had the most nodes per case, ranking ahead of supravestibular and hypopharyngeal lesions in that order, and that the larger the primary node is the more likely there will be multiple metastases In view of the fact that these variables appeared to influence the number of positive nodes per case, and, therefore, the prognosis, it was necessary to determine whether there was any correlation between these factors A careful study of the data failed to reveal any correlation between the site of the primary lesion and the maximum size of the primary node, therefore, it would appear that the site of the primary lesion and the maximum size of the primary node influence the number of positive nodes per case independently of each other, and, therefore, by their effect on multiplicity of metastases have an effect upon prognosis.

Since the survival rate is affected by the number of nodes, and since the umber of nodes per case appears to be related to the site of the primary lesion and the maximum size of the primary node, one would expect that the survival rate would be related to these same factors. Indeed, in this study the survival rate did appear to be related to the site of the primary lesion, however, no such relationship could be demonstrated between the maximum size of the primary node and the survival rate in these 84 patients when the *actual* size of the primary node was used. In a previous study of 75 patients by one of us (G. F. R.), there appeared to be a clear relationship between the maximum size of the primary node and the survival rate when the preoperative *estimated* size of the primary node was used.[7] The size of the sample in the present study and in the previous study is virtually the same regarding survival. Since we had originally used two year survival figures, we compared the node size with the two year potential survivors in this study and again found no difference in survival.

At the present writing, we are unable to account for this difference in our two series, but we feel that difficulties in estimating node size accurately and in differentiating a solitary node from several nodes in one place may explain this difference. We still feel that the estimated size is important in prognosis because of our clinical impressions, the findings of the previous study, and the indirect relationship between actual node size and survival demonstrated in this study.

Although we have compiled many facts of interest, the most important finding to us is the overall three year survival rate of only 17 per cent in those cases with positive nodes. This survival rate is woefully inadequate even for salvage surgery, but is probably an unfair indictment of neck dissection as a curative procedure. Most likely the survival rate in this series is low, because we were relatively unselective in choosing patients for surgery during the period of this study. The operation was offered to practically all patients with cervical metastasis in the *hope* of affecting a cure. Perhaps this philosophy is wrong Perhaps we should be more selective in our choice of patients for radical neck dissection

As a result of the present study we feel that the prognosis in these cases is affected by the site of the primary lesion and the number and apparent size of the metastatic nodes, and that the decision to advise radical neck dissection should be tempered by these factors Perhaps in this way we can more intelligently select patients in whom the potential benefit adequately justifies the operation

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THE DIAGNOSIS AND TREATMENT OF FACIAL PARALYSIS, SECONDARY TO BASAL SKULL FRACTURE*

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Facial paralysis is a not uncommon finding in basal skull fracture Grove,[1] in an exhaustive study of 211 patients with skull fracture, found that 29 had facial paralysis, an incidence of 14 per cent of all skull fractures, and an incidence of 18 per cent of his series in which the fracture involved the temporal bone Fractures of the temporal bone are usually of two types longitudinal and transverse Longitudinal fractures of the petrous portion of the temporal bone are roughly three times as frequent as are transverse fractures Longitudinal fractures usually extend from the squama across the posterior aspect of the osseous external auditory canal, across the tegmen, and along the anterior surface of the petrous pyramid Facial paralysis occurs in longitudinal fractures in 10 to 18 per cent of patients Bleeding from the ear, conductive deafness, and a visible fracture line in the external auditory canal are common findings in longitudinal fractures Transverse fractures of the petrous pyramid are more likely to be fatal, and cause facial paralysis in 30 per cent to 50 per cent of patients Nerve deafness is not uncommon in transverse fractures, hemotympanum may occur, but tears of the tympanic membrane, bleeding from the ear, and a visible fracture of the ear canal are not seen

A third type of fracture involving only the mastoid process has been reported, but is rare -

Facial paralysis incident to fracture of the temporal bone may be immediate or may be delayed and not develop until several days after the injury

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*Read at the Sixty-Second Annual Meeting of the American Laryngological Rhinological and Otological Society Inc Hot Springs Va March 11, 1959

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Spontaneous recovery of function appears to be the usual outcome in facial paralysis associated with skull fracture. Eighty per cent of Grove's cases recovered spontaneously, and Kettel[3] states that 75 per cent of the immediate type recover completely, 15 per cent show partial recovery, and 10 per cent remain completely paralyzed.

Decompression of the facial nerve in the temporal bone in paralysis secondary to temporal bone fracture, has been reported by Cawthorne,[4] Farrior and Caldwell,[5] Behrman,[6] Kettel,[3] Maxwell and Magielski,[7] Feinmesser,[8] and others. The patients operated upon by these authors presented fractures of the longitudinal type, and in most incidences the nerve was found to be damaged by the fracture at or near its pyramidal segment.

Although it is generally conceded that the prognosis for recovery of facial paralysis in closed head injuries is good, recovery does not always occur. Stigmata of degeneration, consisting of weakness or incomplete recovery of the facial muscles, spasmodic tic, and mass movement or synkinesis are common in those patients who do recover function after a reaction of degeneration has occurred.

The facial nerve can be decompressed from the stylomastoid foramen to or near the geniculate ganglion with little morbidity, and without damage to the conduction apparatus. For the above reasons, it is my contention that those patients in whom the fracture is felt to be surgically accessible in the temporal bone, should be operated upon as soon after injury as their general condition permits. In this way it is possible to determine the extent of injury, correct the injury to the nerve, determine any defect of the conduction apparatus, and often prevent a permanent conduction deafness. If reaction of degeneration can be prevented by early decompression, the end-result will certainly be better.

SELECTION OF PATIENTS

Patients in whom a diagnosis of transverse fractures of the temporal bone is made, should not be operated upon. Those with longitudinal fractures involving the nerve distal to the geniculate ganglion are ideal candidates for decompression. In general, if lacrimation is suppressed or absent, a lesion of the geniculate ganglion is present,[9] but Feinmesser[8] reports a patient with absent lacrimation in whom the damage to the nerve was in the pyramidal portion. Immediate paralysis indicates a more severe lesion of the nerve, while a delayed paralysis is probably due to hemorrhage in the nerve sheath and edema of the nerve. The former should benefit more from decompression.

TECHNIQUE

The following technique of facial nerve decompression[10] was employed in four patients with facial paralysis following skull fracture.

A simple mastoidectomy is done, utilizing an endaural incision. The antrum is opened widely, exposing the short process of the incus. The junction of the tympanomastoid suture and the digastric ridge is exposed inferiorly. The posterior and superior aspects of the external auditory canal are thinned, and the middle ear entered with a small burr directed antero-medially at a point just inferior and lateral to the fossa incudis. This opening is enlarged, permitting visualization of the tympanic portion of the facial nerve. The nerve is then decompressed from the cochleariform process to the stylomastoid foramen by removal of bone overlying the postero-lateral aspect of the nerve, with motor driven burrs and dental excavators. A neurolysis is then carried out on the entire exposed portion of the nerve, along its posterior aspect so that the anterolar trunk of the nerve is not damaged. The incision is closed by primary suture without drainage, and without turning a flap.

CASE REPORTS

Case 1. K. A., a 33 year old man, sustained a severe head injury in an oil field accident in August, 1956. He was unconscious for several days. Bleeding from the left ear and complete left facial paralysis were noticed soon after admission to the hospital. Examination on October 11, 1956 revealed complete left facial paralysis of the peripheral type, a fracture line of the posterior wall of the left external auditory canal extending to the annulus, and a conduction deafness in the left ear. Roentgenograms showed a longitudinal fracture of the left temporal bone. He was dis-oriented and uncooperative. On October 20, 1956, two months after the injury a left facial nerve decompression was done.

Two fracture lines extended from the squamous through the osseous external auditory canal, and a fragment of the canal was displaced medially into the fallopian canal. The incus was displaced anteromedially. Bone fragments were removed, and the facial nerve decompressed from the cochleariform process to the stylomastoid foramen. The nerve was found to be severely contused in its pyramidal portion. Neurolysis was done and the incus was rotated into near normal position. Hearing was normal to whisper ten days postoperatively. At last examination approximately six months after surgery, 75 per cent normal function of the left facial musculature was present. Further follow-up of this patient has not been obtained.

Case 2. M DeB., a 13-year old girl was thrown from a horse on Dec. 31, 1956, receiving a head injury. She was admitted to the hospital, where skull X-rays revealed a linear fracture of the left temporal bone. Bleeding from the left ear was noted. Left facial paralysis began 24 hours after injury and was complete the next day. Examination on Jan. 4, 1957, revealed a fracture along the posterior aspect of the left external auditory canal extending onto the tympanic membrane and hemotympanum. She gave a history of having been deaf in the right ear since mumps at the age of six years. Moderate conduction deafness of the left ear and severe nerve deafness of the right ear were shown by audiometric examination. There was no taste disturbance, and lacrimation was excessive on the left. Response to faradic stimulation was normal on Jan. 5, 1957. Electrical testing was repeated on Jan. 20, and loss of response to faradic stimulation and an altered response to galvanic stimulation were noted.

Decompression of the left facial nerve was performed on Jan. 23, 1957, three weeks after injury. A well pneumatized mastoid was found to be filled with old blood, granulomatous tissue filled the antrum and aditus ad antrum, a fracture line extended from the squamosa through the posterior aspect of the osseous external auditory canal just below the fossa incudis. Decompression of the nerve and neurolysis were done and the fallopian canal was found to be fractured in its pyramidal segment. The nerve was not severely damaged. First evidence of return of function was apparent one month postoperatively. Five months after decompression function was approximately 75 per cent that of normal and no further improvement was present one year after surgery. She has slight weakness of the lower face and some mass movement is evident. Hearing is normal in the operated ear.

Case 3. N C, a 31-year old man received a head injury in an automobile accident on Feb. 18, 1957. He gave a history of having bled from his right ear but not his left. Left facial paralysis was noted at the time of injury. Examination on March 15, 1957, revealed complete left facial paralysis of the peripheral type, a dry central perforation of the right tympanic membrane, and hemotympanum on the left. There was no canal fracture visible at otoscopy. There was a moderate conduction deafness on the left, and normal hearing on the right. He denied any disturbance of taste and lacrimation was normal bilaterally. Skull and mastoid X-rays showed no evidence of fracture of the temporal bone, but fractures of both zygoma were shown. Electrical testing of the left facial nerve showed complete reaction of degeneration.

Six weeks after injury there was no return of function, and on April 4, 1957, a decompression of the left facial nerve was done. The nerve was uncovered from the geniculate ganglion to the stylomastoid foramen and no evidence of fracture or of injury to the nerve was found. A neurolysis was done and the nerve appeared normal He was seen again on Oct 19, 1957, at which time about 65 per cent normal function of his left facial musculature was observed His ear healed without difficulty, and his hearing was normal to audiometry

Case 4 C P, a 12 year old boy, was injured in an automobile motor bicycle collision on June 23, 1957 On admission to the hospital, bleeding from the left ear was noted Skull X rays indicated a linear longitudinal fracture of the left parietal and temporal bones Facial paralysis was first noted three days after injury Examination on July 1, 1957, revealed a complete left facial paralysis of the peripheral type, and a fracture line along the posterior wall of the left external auditory canal, which extended onto the tympanic membrane There was blood in the middle ear Moderate conduction deafness of the left ear was present There was no taste disturbance and lacrimation was normal on the left Electrical studies were not done On July 10, 1957, 17 days after injury, a left facial nerve decompression was done A fracture line was found which extended across the squamosa and mastoid process through the external auditory canal into the tympanic membrane, just below the notch of Rivinus A fragment of the external auditory canal was found displaced medially into the fallopian canal in its pyramidal portion Decompression was carried out from just below the geniculate ganglion to the stylomastoid foramen, and a neurolysis was done The nerve appeared contused but not severed

Improvement in facial function was evident 48 hours postoperatively Nine days after surgery he was estimated to have a 90 per cent return of function He was next seen on Sept 12, 1957, at which time his facial function was entirely normal, with no stigmata of degeneration, and an audiogram revealed a normal air conduction threshold in the operated ear

SUMMARY AND CONCLUSIONS

Facial nerve decompression was carried out on four patients with facial paralysis associated with skull fracture Three, (Cases numbered 1, 2 and 4) were found to have moderate trauma to the nerve in its tympanic course In the fourth patient no visible fracture line of the temporal bone was evident on otoscopic or Roentgen examination preoperatively, and no fracture or other pathology was found at operation, however, a transverse fracture through the geniculate area could not be ruled out preoperatively All patients had normal hearing in the operated ear at last examination The best functional result was obtained in the patient operated upon the earliest date after injury

Facial nerve decompression by the technique employed, enables inspection of the nerve and the conduction apparatus without interruption of the ossicular chain and without undue trauma to the patient It is my opinion that facial nerve decompression should be done on patients with facial paralysis secondary to temporal bone fracture, if the lesion is felt to be surgically accessible, as soon as the patient's general state of health permits, providing the patient is seen early after injury Perhaps if this is done a reaction of degeneration can be averted, and a better functional result without synkinesis, weakness or spasmodic tic obtained Irreversible defects of the sound conduction apparatus may be prevented also

In those patients who are first seen late after injury, and in whom a reaction of degeneration has occurred, there should be no particular harm in waiting two months before decompression is advised

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THE PROBLEM OF SINUSITIS IN CHILDREN*

VICTOR R ALFARO, M D ,
and
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Washington, D C

Is sinusitis in children much of a problem today? It is apparent to all of us that we no longer see as many seriously ill children as we did before the era of the antimicrobials Surgery of the sinuses in children is rare today, consequently the problem of sinusitis is primarily one of office treatment and of home management One is impressed by the relatively few cases of serious complications seen in private practice and even in the outpatient clinics of our hospitals Children are getting better care from educated and alert parents who rely more and more on the advice of the general practitioner, pediatrician, and otolaryngologist The widespread use of immunization to an ever larger number of children's diseases, as well as the increased interest in adequate dietary standards and general health measures are factors of great importance in bringing about favorable changes in the character of rhinologic practice, but although the morbidity of sinusitis has unquestionably been reduced in pediatric and adult patients, there has not been a proportionate reduction in their numbers Many of the problems we see can be traced directly to the misuse or abuse of the very agents that we rely upon for treatment of sinusitis One of the major problems is the increasing number of staphylococci and other bacteria, which are resistant to the sulfonamides and penicillin Sometimes this forces upon us the difficult choice of employing antibiotics which are known to cause damage to the neural elements of the ear, to the kidneys, or the hematopoietic system It is imperative to exercise the greatest discrimination in the use of antibiotics, we must, if possible, determine which one to

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use, how much to use, and when to use it Perhaps we are using these "wonder drugs" too soon in many cases, before the natural forces of immunity in the host have been mobilized We are seeing a new type of respiratory disease, characterized by an insidious tendency to chronicity, with a minimum of serious complications, but often with a stubborn resistance to treatment We see this in the sinuses, the ears, the pharynx, larynx, and tracheobronchial tree

ANATOMY AND PHYSIOLOGY

The ethmoids are the only sinuses present at birth[1], the antrum develops rapidly, with a relatively large ostium which allows for adequate drainage After the age of three or four years, the antrum floor descends in the maxilla as the facial bones grow, and at this time the ostium becomes smaller The sphenoids grow slowly and the frontals are the last to develop All the sinuses achieve their adult size and shape at puberty

The mucosa of the sinuses is contiguous with that of the nose and is histologically similar The ciliated epithelium is covered by a thin blanket of mucous which moves toward the ostia Proetz[2] has stressed the importance of the integrity of the cilia and mucous blanket to the health of the sinuses and nose Anything which destroys or suppresses this function will reduce the resistance of the mucosa to infection In infancy, infections of the ethmoids occur with almost every severe cold, and in early childhood the antrum is frequently involved, but most of these infections clear up spontaneously if the general health is good

BACTERIOLOGY

Studies by Goldman[3] have shown that the nose is relatively sterile, while potential pathogens are present normally in the nasopharynx The nose is kept free of pathogens by the natural antibacterial substance, lysozyme which is present in the protective mucous blanket, and the ciliary action which keeps bacteria and foreign substances moving from the nose and sinuses into the nasopharynx When resistance is lowered, the pathogens from the nasopharynx can invade the nose and sinuses and the tracheobronchial tree Cultures of the nose

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Heinberg[4] discusses the problem of resistant bacterial strains, especially the staphylococcus Whereas the streptococcus formerly headed the list of organisms found in otorhinologic practice, now the staphylococcus is the most common Heinberg divides staphylococci into the two major groups saprophytic and pathogenic The latter are carried constantly on the skin or in the nasopharynx by about 50 per cent of the population and can give rise to serious infection The coagulase test is the most reliable single, *in vitro* test for the identification of pathogenic staphylococci, which are coagulase positive After determining that the staphyloccus is coagulase positive, sensitivity tests should be done

ETIOLOGY

General Resistance

Acute sinusitis in children is in most instances a complication of the common cold Because of this, any factor which results in frequent colds must be considered as a potential cause of sinusitis, thus we see more sinusitis in children during the winter months and among families of lower economic status Anything which lowers the child's resistance, such as inadequate diet, clothing, or shelter can predispose to sinusitis In discussing lowered resistance, the existence of hypogammaglobulinemia should be considered Although there is much to be determined regarding the relationship of Gamma globulin levels to respiratory and other infections, recent studies seem to indicate the probability that reduction in Gamma globulin is an important factor in susceptibility to infection A recent article in *Lancet* divides agammaglobulinemia into congenital and acquired The former is described as occurring almost entirely in males, and may be a sex-linked recessive trait The acquired form may be suspected in children of either sex, in whom recurrent bacterial infections have become prominent without other cause, and in whom the Gamma globulin level is below 100 mgm /100 ml The deficiency is less complete than in the congenital disease, and there may be some antibody formation to a few antigens, but not to most Enlargement of the spleen and lymph nodes is common

Impaired Nasal Physiology

Any abnormalities which result in inadequate ventilation and stasis of secretions in the nose and sinuses can lead to infection Of particular importance are hypertrophied adenoids, choanal atresia, deviated nasal septum, and enlarged or deformed turbinates One of the basic concepts in the treatment of sinusitis is to restore normal nasal physiology, and it is frequently necessary to correct anatomical abnormalities in order to establish adequate ventilation and drainage

Allergy.

Allergy plays a major role in sinusitis, and must be considered whenever the diagnosis of sinusitis is made Allergic rhinitis causes edema of the mucosa, an altered mucous blanket and ciliary activity is impaired Polyps, though uncommon in children, may further interfere with ventilation and drainage The allergic child will more frequently have a chronic sinusitis which resists treatment unless both the allergy and the infection are treated Evans[6] quotes Shambaugh, who states that "at least 70 per cent of chronic sinus infections and at least 90 per cent of chronic nasal infections can be shown to have an underlying allergic factor responsible for the chronicity."

Dental Infections

Infections of the antrum in older children may result from poor dental hygiene, periapical disease, or trauma in extractions This factor, however, is relatively rare in comparison to maxillary infections in adults

Barotrauma

In this modern age, both adults and children are being subjected to sudden and severe changes in barometric pressure These changes, whether in modern flight or in under water swimming and diving, can cause sinusitis

SYMPTOMATOLOGY

Acute Sinusitis

Younger children are more prone to have systemic reactions such as high fever, toxemia, and severe prostration In milder cases there may be anorexia, lassitude, or simply a general decrease in the child's well-being and loss of interest in his usual activities Older children tend to have the same symptoms as adults In allergic children, we see less of the severe, toxic symptoms and more of the general loss of well-being Purulent rhinorrhea, nasal obstruction, sore throat and cough are usually present Many of the younger children cannot or will not blow their nose, and the copious post-nasal drainage finds its way to the tracheobronchial tree, resulting in an annoying cough, loss of appetite and even vomiting may occur if much of the secretion is swallowed Anosmia may be present, owing to the swelling of the mucosa in the olfactory area Acute otitis media is a frequent complication

Chronic Sinusitis

The most consistent finding in the chronic cases is a history of repeated respiratory infections beginning in the Fall and lasting until Summer Associated with the typical nasal symptoms there is usually cough and frequent involvement of the ears In some cases, nasal symptoms are minor, and the chief complaint will be cough In others, the sinusitis is discovered while attempting to find the cause of recurring secretory otitis

Because the symptoms vary with the sinus or sinuses involved, this fact may be used to aid in the diagnosis In ethmoiditis, there is headache between and behind the eyes, or in the temporal region, pressure on the globe of the eye may be painful In severe cases with orbital involvement there is a typical lateral displacement of the eye

In acute antrum infections there is pain and tenderness over the involved maxilla In chronic maxillary infections, pain and tenderness are less prominent, nasal obstruction on the infected side is usual and purulent rhinorrhea varies from scant to copious Occasionally an older child may complain of toothache and mistakenly consult a dentist

The frontal sinus is much less commonly involved than the maxillary and ethmoids, it sometimes accompanies an acute anterior ethmoiditis in older children There may be tenderness to pressure or percussion over the anterior wall of the sinus, but the floor is more commonly tender to palpation In severe cases with poor drainage through the naso-frontal duct, the pain may be excruciating When there is a thin anterior wall or a dehiscence present, the pus may escape from the sinus and form a subperiosteal abscess Involvement of the orbit usually results in edema of the upper lid and a downward displacement of the eye

The sphenoid sinus is infected rarely without involvement of the other sinuses especially the posterior ethmoids Sphenoiditis may be present without symptoms, and will not be discovered unless it is particularly searched for Pain may be referred to the forehead or eye on the involved side Occasionally, edema of the upper lids without proptosis may be seen Secretions from the sinus drain into the nasopharynx, together with secretions from the posterior ethmoids and cause pharyngitis with thickening of the lateral pharyngeal bands and enlarged posterior cervical nodes

DIAGNOSIS

The diagnosis of sinusitis in children as in adults, must be made with a systematic evaluation of the history, symptomatology and clinical findings A careful history is most important, to determine the general health of the child with particular reference to the frequency of colds, cough, low-grade fever, nasal obstruction and rhinorrhea A special inquiry should be made regarding possible allergic factors such as a family history of allergy, seasonal hay fever, asthma, feeding problems which may have an allergic basis, and allergic dermatitis

The examination of the nose should establish the presence of pus, deviation of the nasal septum or evidence of allergy such as paling of the mucosa, watery discharge or nasal polyps The nasal mucosa should be decongested by a spray or tampon of a vasoconstrictor, such as ¼ per cent phenylephrine hydrochloride (Neosynephrin) Placing a small cotton pack against the middle and inferior turbinates will reduce their size and facilitate location of the source of the pus and inspection of the posterior portion of the nose A large adenoid mass may be seen blocking the choanae In some cases, nasopharyngoscopy is useful in locating the source of pus, and inspecting the nasopharynx for adenoids After the nose has been examined thoroughly, the oropharynx should be examined for postnasal discharge, and its color and consistency noted In long-standing cases, the lateral bands are usually hypertrophied, and the posterior pharyngeal wall has a pebbly appearance Purulent secretions are seen along one or both lateral gutters

In older children, as in adults, transillumination and X-ray are of considerable diagnostic significance In younger children, because of the relative thickness of bone to airspace and the presence of unerupted teeth, they may not be as helpful

Nasal secretions should be examined carefully First, their anatomical source should be determined, that is, whether they are from the anterior or posterior group of sinuses When the secretion is purulent, it should be smeared, cultured, and tested for sensitivity to the antibiotics

If allergy is suspected from the history, or eosinophils are found in large numbers in nasal smears, skin tests should be done Pollen and inhalant tests are quite reliable, but food tests are not The elimination diets of Rinkel are helpful, the common offenders are wheat, milk, eggs, chocolate, corn and peanuts

PREVENTION AND TREATMENT

Because the majority of sinus infections are complications of the common cold, much of the prevention deals with the avoidance of colds Recent advances in virology are encouraging indeed, but until we have specific, effective vaccines, we must endeavor to raise the child's general resistance and reduce his contacts with others who have respiratory infections This is admittedly difficult, particularly in children of school age The child should have a good diet, adequate rest and proper supervision of his physical condition In this regard, attention should be paid to the importance of chilling and exposure Children are notoriously inept at recognizing when they are cold They can get chilled while playing outdoors if improperly dressed, or if they get wet, furthermore, young children who are restless sleepers will often toss their blankets in their sleep and become chilled as a result of exposure if their window is wide open Parents should be instructed to ventilate the room for a short while when the child goes to sleep, and then close the window for the night Proetz[2] has pointed out the harmful effects of dryness of the respiratory mucosa Forced air heat, when not humidified at its source is particularly noxious, not only because of the drying effect, but also because of the house dust it circulates

Van Alyea[8] stresses the importance of supportive measures in the treatment of sinusitis The child should be made as comfortable as possible General prostration, which occurs frequently in small children, should be treated with bed rest, and pain should be relieved by aspirin and hot packs to the face A vaporizer in the child's room helps to improve the humidity and relieve the dryness of the respiratory tract The care of these children is usually a cooperative effort with the pediatrician or family physician They are chiefly concerned with maintenance of the highest possible index of general health in the child In this respect, the treatment of hypogammaglobulinemia in infection prone children is usually handled by them We have seen several children with chronic or recurring sinusitis who are under treatment for this deficiency Although results are not always spectacular, the maintenance of adequate levels of Gammaglobulin appears to be a valuable adjunct in the overall treatment

An editorial[9] in "Clinical Proceedings of the Children's Hospital, Washington, D C" states "Frequently, a dose of Gammaglobulin in 0 1 gm per kg of body weight will afford quite satisfactory protection against repeated infection" This injected Gammaglobulin has a half-life of from 14 to 20 days and probably should be repeated every three or four weeks Intravenous injection is warned against, as severe hypotensive reactions invariably occur

Dolowitz and his co-workers[10] studied hypogammaglobulinemia in relation to thyroid function They reasoned that since thyroid secretion produced an increased lymphocytosis and increased protein metabolism, it might increase the circulating Gammaglobulin Thus they used sodium liothyronine (Cytomel) which acts on the peripheral tissues, producing immediate results It is absorbed readily from the gastrointestinal tract and is rapidly cleared from the blood stream, thus the oral route of administration was the most satisfactory as well as the most effective They found that this drug raised the level of Gammaglobulin and appeared to have beneficial effects in the treatment of a variety of infections Although the number of cases reported is small, the results are significant enough to warrant further study

Office Treatment

Every effort is made to obtain early rapport with the child by handling him gently and explaining every step of the examination and treatment In most cases adequate cooperation can be obtained, this should be done even if we have to limit the first treatment or two to the simplest of procedures in order to gain his confidence Our primary concern is to establish good ventilation and drainage The first step is the shrinking of swollen turbinates by a vasoconstrictor spray or nose drops, after a few minutes a cotton pledget of the vasoconstrictor is placed in the middle meatus, under the middle turbinate, if possible The pack is allowed to remain in position for several minutes and after removal, spot and mass suction are used to remove thick secretions from the floor of the nose and middle meatus Care must be exercised not to use too great an intensity of mass suction, as this is painful and may cause greater congestion and blockage Following suction, the nose is irrigated with normal saline, using a three ounce Asepto-syringe with curved tip The patient is instructed to lean his head forward, hold his breath and open his mouth as this is done, large quantities of thick, mucopus can be removed from the nasal cavities by this procedure

The use of argyrol packs has been decried by many in recent years, because of the inhibitory action on the cilia, nevertheless, we still find them extremely useful Their chief virtue is to produce a slight irritation of the mucosa which causes hypersecretion and stimulates the drainage of pus from the sinuses, particularly the ethmoids After the packs are removed, the nose is irrigated with saline as described above We are aware of the danger of argyria from the abuse of silver preparations, and because of this we do not prescribe argyrol for home use Under controlled office conditions, however, it is free of danger Its only objection is the messiness

The value of the Proetz displacement treatment in infections of the ethmoids and sphenoids should be re-emphasized The technique is so well known that we do not need to review it here Children tolerate this procedure very well

When infections of the antrum do not clear up quickly, irrigation should be done through the natural ostium or by an inferior meatus puncture Irrigation through the ostium is much less distasteful to the patient, and in our hands about 80 per cent can be irrigated by this method Our technique of antrum irrigation has been described by one of us[11] in a previous publication, but will be reviewed briefly A small, cotton-tipped wire applicator is dipped in 5 per cent Cyclaine mixed with 1/1000 epinephrine in the proportion of five to one This is placed at the site of puncture or the natural osteum for several minutes, and repeated two or three times until firm pressure elicits no pain By this method, necessary analgesia can be achieved at the desired spot without massive exposure of the nasal membranes to the anesthetic agent So far, we have seen no reactions to the Cyclaine When the natural osteum cannot be entered easily we prefer not to puncture the middle meatus

For the inferior meatus puncture, we use the Lichtwicz needle After it has been passed into the antrum, a wire stylet is passed through the needle This dislodges any spicules of bone which may occasionally obstruct the lumen, by having the length of the stylet marked, it can be used as a guide to determine how far the tip of the needle is from the walls of the sinus.

Whether the antrum is entered through the natural ostium or the inferior meatus, much discomfort can be produced by the pressure of the irrigating solution, therefore, it is important that only moderate pressure be used, not only with the solution, but also with the air that is blown in after the irrigation Air should never be used if there has not been a free flow of the solution The possibility of serious air embolism must not be forgotten The instillation of 2 cc of an antibiotic vasoconstrictor solution seems to be helpful in some of the more chronic cases

HOME TREATMENT

The home treatment, as the office treatment, rests on the principle of establishing drainage This is aided by the use of plain vasoconstrictors, or by one of the nasal sprays that combine vasoconstrictor, antihistamine and antibiotic or Cortisone These combination sprays seem to be more effective than the vasoconstrictor alone, particularly in allergic cases, however, with the use of any drug that is instilled in the nose, it is important to caution the parent against overuse In their natural anxiety to open a blocked nasal passage, the drops or spray may be used too often, and the dangers of this must be emphasized Oral decongestants are also helpful when nasal obstruction is severe

Infants and even older children are unable to blow secretions from the nose, and it is important that the parents have some means of removing them The Davol Infant Nasal Aspirator is a simple, inexpensive device that can be obtained at any pharmacy It consists of a rubber bulb with a glass nasal tip which fits snugly in the nostril Suction is obtained by releasing the bulb while the other nostril is held shut When the nose is filled with thick secretions, the aspirator can be used before the vasoconstrictor is used, in order to allow the drops or spray to flow into the nasal cavity, and again afterwards to draw out more secretions

Antibiotic Therapy

The use of antibiotics has been extremely helpful in the treatment of sinusitis, particularly in acute cases The choice of antibiotic is best determined by culture and sensitivity tests, however, in the presence of severe infections, antibiotic protection should be afforded immediately, the results of the tests when completed can then be correlated with the therapeutic response to the drug already given It is not uncommon to find the antibiotic we are using is producing an adequate therapeutic response, yet is listed among those to which the bacteria exhibit strong resistance *in vitro* Penicillin is no longer our first choice, because of the large number of organisms which are resistant to it, furthermore, allergic reactions are increasingly encountered in previously sensitized patients In this respect, it seems that topically used penicillin, in nose drops, lozenges and aerosols is particularly prone to sensitize the patients At the present time we prefer to start our patients on one of the tetracyclines or erythromycin Chloramphenicol, furadantin, and triacetyloleandomycin are all effective against the staphylococci When fluid intake can be assured in the older children, the sulfonamides such as sulfasoxasole are often very effective.

Although it is not practical to do routine sensitivity tests on every patient, they should be done in all cases of severe infection, or when there is no response to the antibiotic after 48 to 72 hours It should be stressed that antibiotic therapy is an adjunct to the well established office procedures, and should not be relied upon as the exclusive treatment

Allergic Treatment

Evans[6] emphasizes the importance of differentiating allergic and infectious sinusitis, and states that many cases of allergic sinusitis can be improved greatly by the simple remedy of stopping all nasal medication and treatment These allergic noses have been irritated and the symptoms aggravated by the attempt to treat an allergic condition as an infectious sinusitis When the diagnosis of allergy has been established, the management of the case will depend upon elimination of those foods and other offenders which can be properly controlled and hyposensitization to the house dust and other inhalants which cannot be avoided

In chronic allergic sinusitis, where polyps are present, it may be necessary to remove them to improve ventilation and drainage Occasionally, under proper hyposensitization therapy small polyps will disappear As previously stated, however, polyps are usually less common in allergic children than in adults

Antihistamines are useful in reducing the rhinorrhea, and in combination with oral decongestants they are particularly effective

Recognition of allergy, and intelligent allergic management by the rhinologist have been factors of tremendous importance in reducing the morbidity of sinus disease We are indebted to Hansel for the impetus which he has given to this most important aspect of rhinology

Radiation Therapy

Radiation therapy for recurring sinusitis in children was used rather extensively a few years ago, reduction in the size of lymphoid tissue as suggested by Levy[12] would presumably aid in the effort to insure good drainage In recent years, however, the possibility of radiation hazards has been stressed, principally in connection with the development of thyroid cancer in children An excellent paper on this subject was presented by Baron[13] to this Society last year One must agree with his conclusion that unless the etiologic connection of irradiation to thyroid cancer can be disproved, it is unwise to use radiation in children if other forms of therapy are available

SURGERY

When conservative management fails to control an infection of the maxillary sinus a window is occasionally necessary The need for a Caldwell-Luc is extremely rare in children Orbital complications which do not yield quickly to conservative treatment, require surgical intervention with an external approach, whether they are secondary to ethmoid or frontal sinus infection

Adenoidectomy is sometimes necessary in order to cure infections of the posterior sinuses In many of these children we have the added problem of recurring otitis media and the adenoidectomy or adenotonsillectomy is of great value

COMPLICATIONS

Before the advent of the sulfonamides and antibiotics, the complications of sinusitis were common and serious The infection frequently spread to cause an orbital cellulitis, osteomyelitis of the skull, meningitis, cavernous sinus thrombosis or brain abscess Today, these are very rarely seen The most common complication is secretory otitis which does not respond to treatment Another frequent complication is cough which clears up only when the sinusitis has been cured In others, chronic bronchitis may end in bronchiectasis Dickey[14] in a discussion of Kartagener's Syndrome, where sinusitis and bronchiectasis are present with *situs inversus*, stresses that treatment for either condition alone is not successful, and, therefore, both must be treated simultaneously Chronic sinusitis which is resistant to treatment is usually part of the clinical picture in cystic fibrosis of the pancreas, and here again bronchiectasis is a common complication Most of these children unfortunately do not survive

SUMMARY

The successful management of sinusitis in children requires the cooperation of the pediatrician or family physician and the rhinologist The present conservative approach in the treatment of sinusitis is based upon four important principles

1 Maintenance of the highest possible level of general health

2 Establishment of ventilation and drainage

3 Recognition and control of allergy

4 The judicious use of the antimicrobials

It is encouraging that general acceptance of these principles by pediatricians and rhinologists has resulted in a marked reduction of the serious complications which require radical surgical intervention

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DESTRUCTIVE LESIONS OF THE TEMPORAL BONE*

RALPH ARNOLD, M D ,
and
GEORGE BAYLIN, M D , (By Invitation),

Durham, N C

Destructive temporal bone lesions have been a particular challenge in diagnosis since the advent of our antibiotic-chemotherapeutic era, with the marked diminution in the number of acute coalescent purulent mastoiditis cases The reduction in the acute infectious mastoids, plus Lempert's endaural approach to the temporal bone, has stimulated a desire to find a better means of diagnosing and treating these lesions which too often can be diagnosed only by means of an exploratory exposure and biopsy of the temporal bone pathology

History, physical examination, laboratory work and radiological study are the preliminary tools at our disposal in arriving at a diagnosis The symptoms and signs are not ordinarily pathognomonic of a particular entity Common symptoms and signs of temporal bone lesions are certainly dependent upon which intrinsic or extrinsic structure is affected Some common symptoms and signs that arise with destructive temporal bone lesions are

Otalgia—Mild, severe, intermittent

Hearing Loss—Conductive, perceptive, mixed

Otorrhea—Serous mucoid, purulent, bloody

Tinnitus—Low pitched, high pitched, vascular

Less common symptoms and signs are

Infection—Meningitis, cerebritis, brain abscess

V, VI *Nerve Involvement*—Anterior apical lesions

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VII Nerve Improvement—Middle ear, mastoid, petrous apex

VII, VIII Nerve Involvement—Internal auditory meatus, cerebellopontine angle

IX, X, XI Nerve Involvement—Jugular foramen

III, IV, V, VI Nerve Lesions—Superior orbital fissure, cavernous sinus, sphenoid

Neurological deficits in combination with any combination of cranial nerves

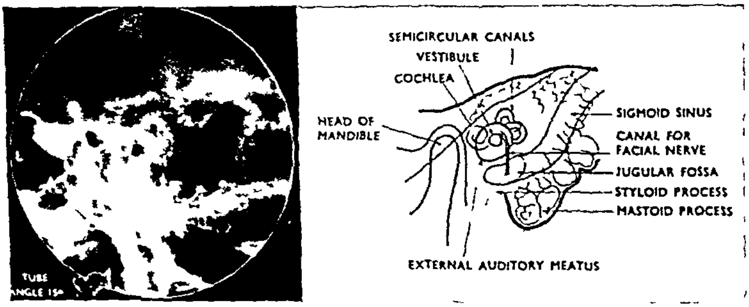

Fig 1 Lateral mastoid Law's position

Radiographic study consists of initial scout films of the Law's position of each mastoid, wherein the internal auditory canal is superimposed on the external auditory canal

From this view one can ascertain

1 The size of the mastoid process and its development with cell type integrity,

2 The position of the tegmen with relation to the external auditory canal,

3 The position and integrity of the lateral sinus plate,

4 The integrity of the anterior canal wall and temperomandibular joint,

5 The integrity of the hypotympanum,

6 The size of the facial canal, *i e*, vertical portion if more K-V is used,

7 A clue as to whether further study of external auditory canal is indicated

The second scout film used is a modified Towne view, or McMillan view of the petrous apices, which is an anterior posterior projection onto the plate

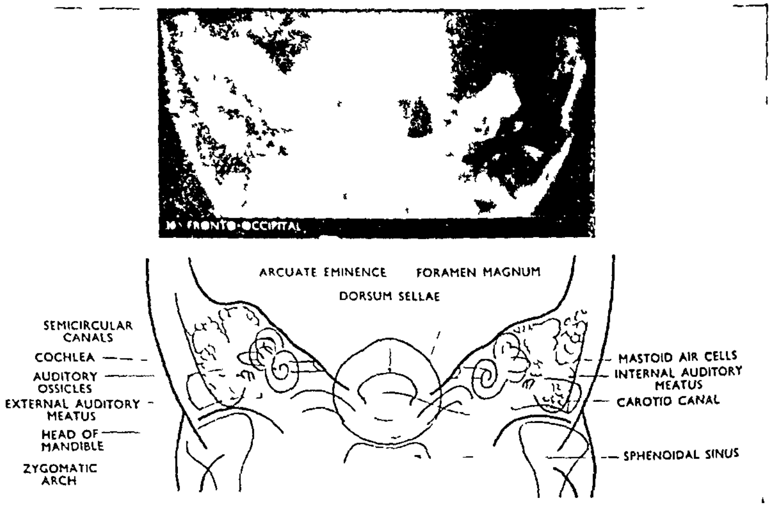

Fig 2 Fronto-occipital view petrous apices

As all technique factors as to K-V, position, and penetration are equal for the two sides, small differences are more readily seen From this view, one can usually evaluate, *1* external auditory canal changes, *2* internal auditory canal changes, *3* mastoid antrum changes, *4* epitympanic changes, *5* middle ear changes, *6* petrous apex changes, *7* mastoid tip changes, *8* eustachian tube changes, *9* ossicular destruction at times Right and left Stenver's views are taken for further internal auditory canal studies Other studies used when necessary are in stereoscopic views as follows *1* mento vertex, *2* petrous apices through the orbits—posterior, anterior, *3* modified Towne

The mento-vertex view permits evaluation of the base of the skull as well as of the temporal bone anatomy One can assess, *1* the middle ear, *2* ossicle position, *3* foramen lacerum, *4* basi-occiput, *5* internal auditory canal, *6* foramina spinosum and ovale, *7* pharynx, and *8* the posterior bony palatal area

Stenver's view is used for study of the internal auditory canal, the semicircular canals, vestibule and cochlea

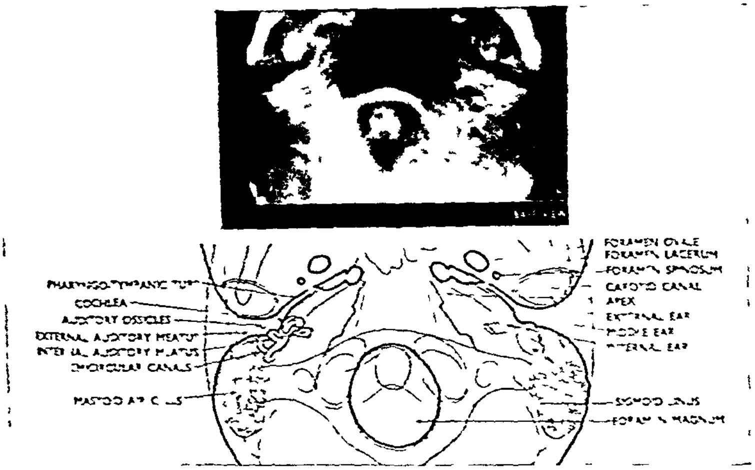

Fig 3 Base View

On occasions, a contrast media such as lipiodol is used to obtain more information about the extent and ramifications of the destroyed area

The following tables are lesions that we have seen over the years, especially in the past ten years

TABLE I

CLASSIFICATION OF DESTRUCTIVE LESIONS OF THE TEMPORAL BONE

A CONGENITAL— *1* Cholesteatoma verum

B INFLAMMATORY—*1* Acute mastoiditis with air cell coalescence, *2* Pseudo-cholesteatoma, *3* Osteomyelitis

C NEOPLASTIC—*1* Glomus jugularis *2* Neurofibroma, *3* Acoustic neuroma *4* Carcinoma *5* Lymphoepithelioma *6* Cylindroma *7* Carcinoma of the naso-pharynx *8* Endothelioma, *9* Plasma cytoma *10* Sarcoma *11* Hemangioma, *12* Irradiation necrosis *13* Rhabdo-myosarcoma, *14* Schwannoma

D IDIOPATHIC OR ANATOMIC—*1* Large sigmoid sinus knee *2* Over-expanded air cell *3* Xanthomatosis, *4* Destruction by increased intra-cranial pressure

TABLE II

DESTRUCTIVE LESIONS SEEN IN PAST TWENTY YEARS—DUKE HOSPITAL

Lesion	Number
Cholesteatoma verum	1
Acute mastoiditis with coalescence of air cells	16 (since 1946)
Pseudo cholesteatoma	213
Glomus jugularis	8
Acoustic neuroma (Neurosurgical service)	54
Neurofibroma	1 (VII nerve)
Carcinoma (external auditory canal)	21
Lymphoepithelioma (nasopharynx, involving petrous apex)	6
Cylindroma	3
Carcinoma (nasopharynx, involving petrous apex)	6
Endothelioma	1
Plasmacytoma	1
Sarcoma	1
Hemangioma	1
Irradiation necrosis	1
Rhabdo myosarcoma	1
Schwannoma (VII nerve)	1
Large sigmoid sinus knee	2
Over expanded air cells	1
Xanthomatosis	3
Squamous decalcified from increased intracranial pressure	1

CHOLESTEATOMA VERUM

Duke History C-29465—W R B, a white man, age 41, had a long history of pulmonary tuberculosis, which resulted in a left pneumonectomy His ear history dated back three years prior to admission for otorrhea At examination the drum had a crust over it, extending down to the canal wall When the crust was removed, a draining fistulous tract could be seen coming through the posterior canal wall lateral to the drum A catheter was inserted into this area, cholesteatomatous debris was aspirated, and iodized oil put into the cavity Roentgenograms revealed a destructive lesion, which was inferior to the mastoid and posterior to it, with a very large area of rarefaction in the zygomatic region

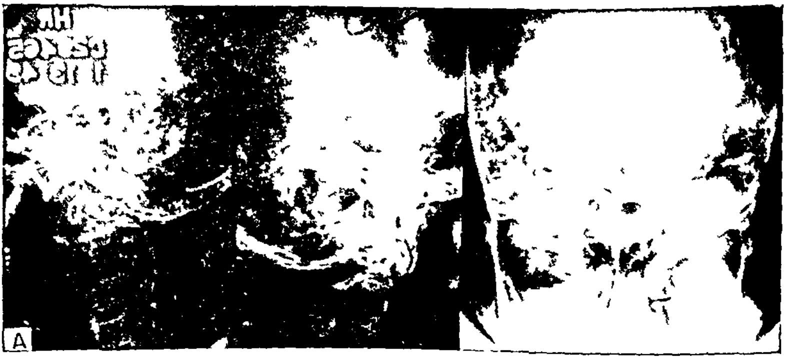

Fig 1A

At operation a cholesteatoma verum was found which did not communicate with the mastoid air cells but went posteriorly toward the cerebellum and posteriorly to the lateral sinus. The mastoid cavity was entered primarily because of the large area of rarefaction in the zygomatic area, and when the mastoid process had been traversed it was found that the area of rarefaction was a clear normal pneumatic cell. The cavity was packed and treated as a radical mastoidectomy postoperatively.

With the history of chronic otorrhea and very little pain, perhaps we should have been able to arrive at this diagnosis, especially after iodized oil was put in, but we did not make the diagnosis until the cavity was opened and its extent verified. The very next patient we saw who had a similar defect and history, did not have the same lesion, hence, it would be difficult to say that from a roentgenological standpoint we could make this diagnosis, it would have to be included in a differential diagnosis.

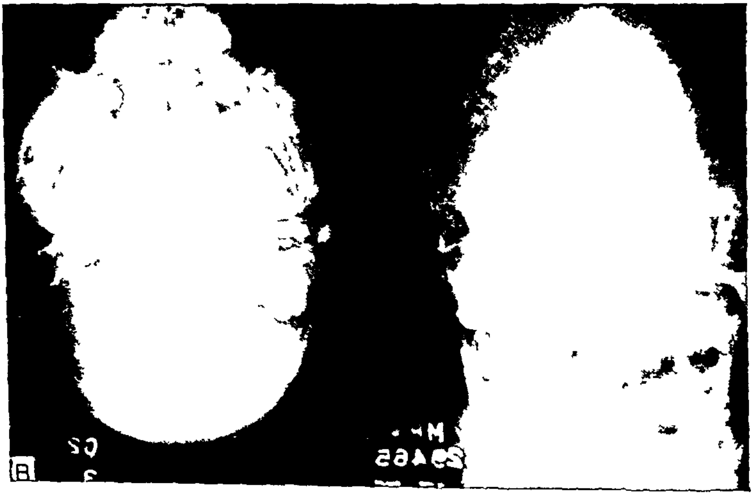

Fig. 1B

ACUTE MASTOIDITIS WITH COALESCENCE OF CELLS

Duke History D 9682—R. M. P., age 19 months, a colored female, was admitted to Duke Hospital with a fever and swollen ear of seven days' duration. There had been otorrhea for six days. It had been treated with sweet oil and when the ear became swollen to a marked degree the mother brought the child to the hospital. The child had received no medical care prior to this time. On admission the child's temperature was 39.5, respiratory rate 36, pulse 150. There was swelling in the retroauricular area over the right mastoid and the ear was at a right angle to the head. The canal was filled with a purulent discharge. The swelling extended on to the temporal region. There was no stiffness of the neck nor any other sign of meningeal irritation. Roentgenograms revealed a 1.5 cm area of decreased density over the mastoid process showing complete coalescence of cells. On the left there was minimal pneumatization.

A classical *retroauricular* incision was made and a subperiosteal

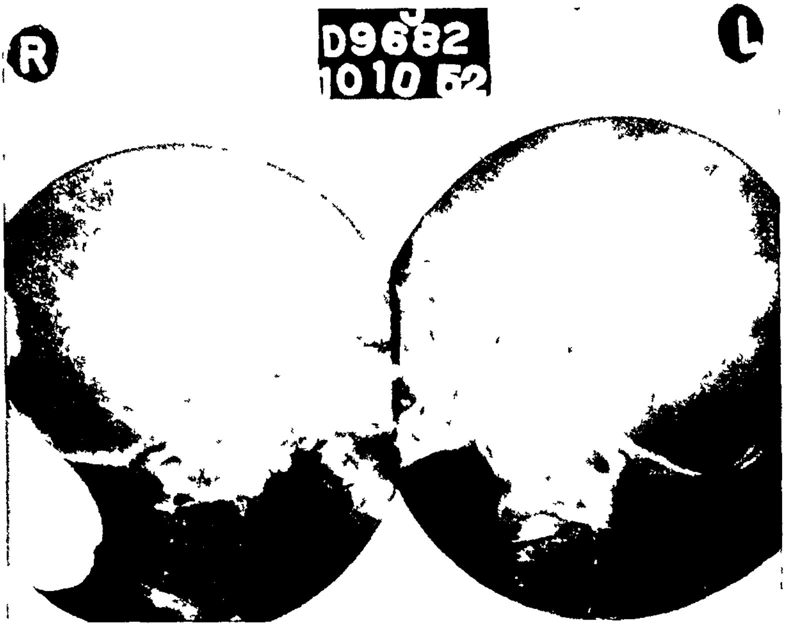

Fig 2

abscess was found with erosion of the cortex Granulation tissue was found in the few mastoid air cells and antrum that were present

Our interest in reporting this case is that this is the fourth acute mastoid that we have seen at Duke Hospital in six years

PSUEDO CHOLESTEATOMA

Duke History C 82036—J W B, age 18, a white male, had had a chronic

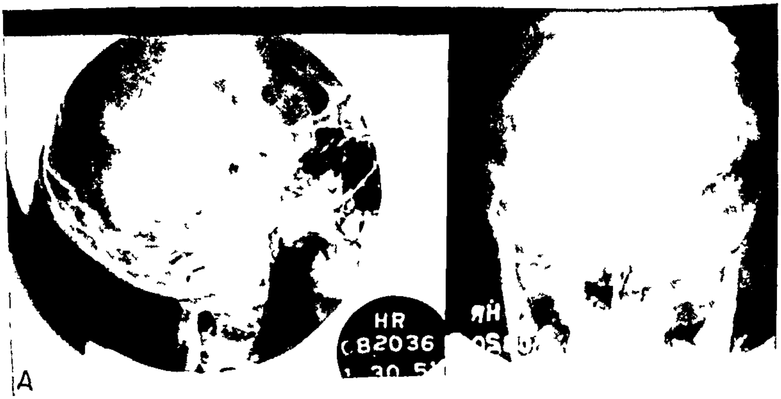

Fig A

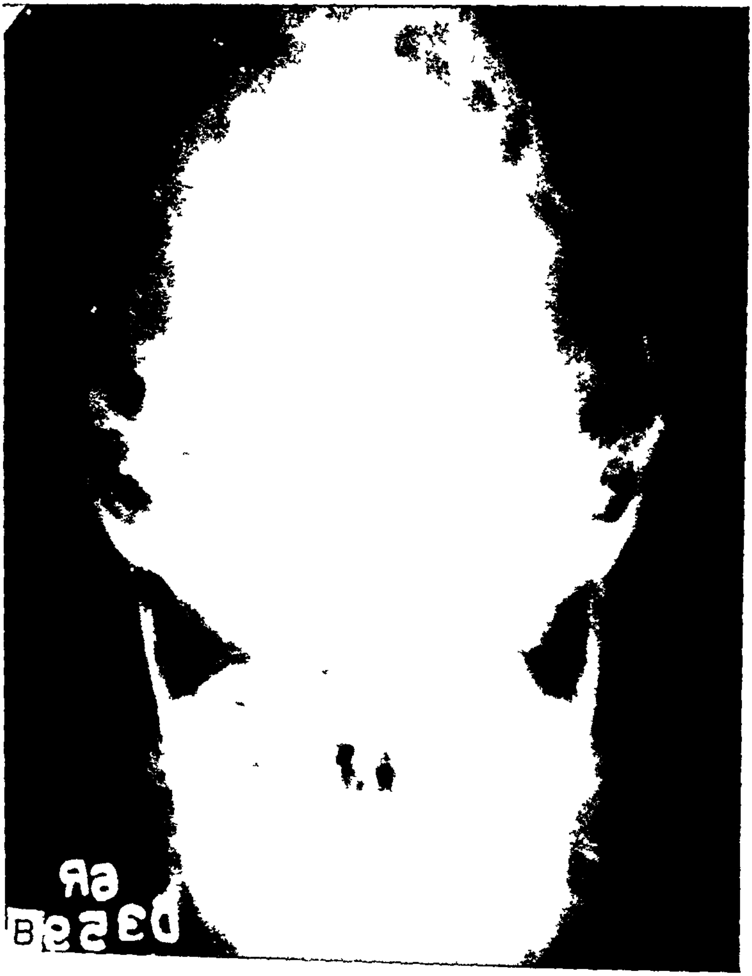

Fig 3B

otitis media since the age of 4 He had had polyps removed from his right ear His left ear quieted down earlier in life but the right ear never had Examination revealed the left drum to be scarred but otherwise normal The right canal was filled with purulent discharge He had a polyp coming through his central perforation Roentgenograms of the mastoids revealed a normal looking left mastoid whereas on the right there was a large destructive lesion which was interpreted as a pseudo cholesteatoma

At operation through an end aural incision a large cholesteatoma was found which was aspirated and a routine radical mastoidectomy was done The skin of the external auditory canal was laid into the cavity, and the patient was returned to the recovery room

The pathological diagnosis was pseudo cholesteatoma

This is the usual history of otorrhea and minimal otalgia, with the roentgenographic findings

OSTEOMYELITIS

Duke History 46896—R B C, age 52, a white man, gave a history dating back to 1934, at which time he had an idiopathic osteomyelitis of the skull

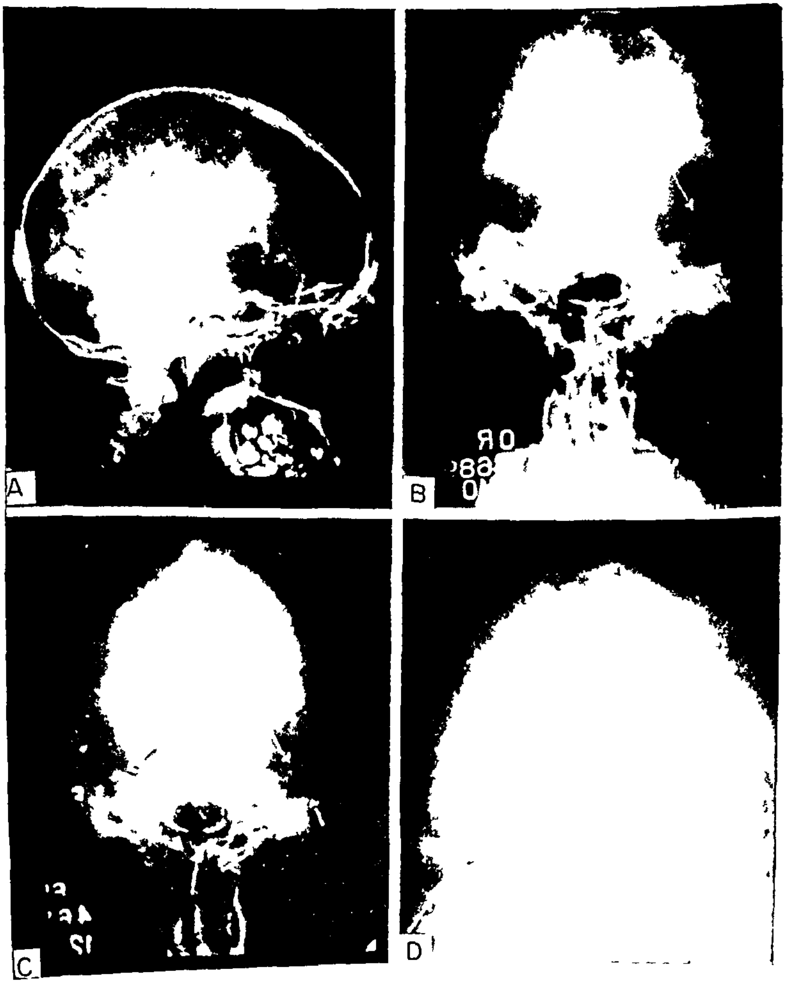

Fig 1—A-B-C-D

with drainage of a temporal abscess This osteomyelitis of the cranium progressed and then began to regress Hospitalization was necessitated for almost the entire year of 1935 At this time he had an acute left mastoiditis with operation, that is, a simple mastoidectomy In 1937 he sequestrated the semi circular canals and cochlea which were removed surgically through a retro auricular incision During the war years he developed a duodenal ulcer, and in 1948 he was admitted to the hospital with the following findings For five or six years he had complained bitterly about pain in his right ear, which had become completely deaf, and he had an upper right facial paralysis, he already had a complete left facial paralysis Hearing was gone on both sides Examination revealed an otorrhea on the right, and tenderness over the mastoid Roentgenographic examination serially followed, gives a good picture of this man's course In brief, he had osteomyelitis that gravitated to both temporal bones, and in sequence sequestrated first his left and then his right cochlea and semi-circular canals, necessitating the removal of both He is now cured of both his osteomyelitis and his otorrhea he has no difficulty in walking and communicates very well by pencil and paper He can talk, but because of his facial paralysis he has difficulty in pronouncing his words, and he finds it is simpler to communicate entirely by writing

This is a case of osteomyelitis of the skull that settled in both temporal bones, sequestrating both cochleas and semi circular canals He has a complete facial paralysis on the left and partial return of function on the right

GLOMUS JUGULARIS

Duke History 48008—M B P, a white woman, age 32 was first seen at Duke Hospital in 1935 with a history of draining right ear of four months' duration and paralysis on the right side of the face of two weeks' duration Prior to admission she had a history of tinnitus for two years, but no otalgia except just at the time of admission She had a long history of right sided headache, vertigo, nausea, and vomiting Clinically and by roentgenogram she presented a diagnosis of mastoiditis The pathological specimen sent to the laboratory was diagnosed as chronic osteomyelitis

This was the same diagnosis that was given five years later when she was re operated upon because of a history of recurrent bleeding otorrhea and otalgia

It was not until nine years later that we made the correct diagnosis of glomus jugularis, which was an unknown entity until Rosenwasser reported the first case in 1945

Transfusion surgery, and irradiation resulted in a cure in this case Irradiation was used to sclerose the vascular element of the tumor

The history of bleeding, otorrhea otalgia, and cranial nerve paralysis would now give us a lead that we might be dealing with glomus jugularis Since we have been looking for these cases we have had four The roentgenographic picture of destruction in and about the jugular bulb, with secondary involvement of the mastoid, should lead one to suspect or entertain the diagnosis of this benign lesion which can be irradiated if the diagnosis is made Roentgenograms are of a great deal of value in this entity plus the seeing a hemorrhagic skin or drum covered mass Biopsy or removal gives the correct answer

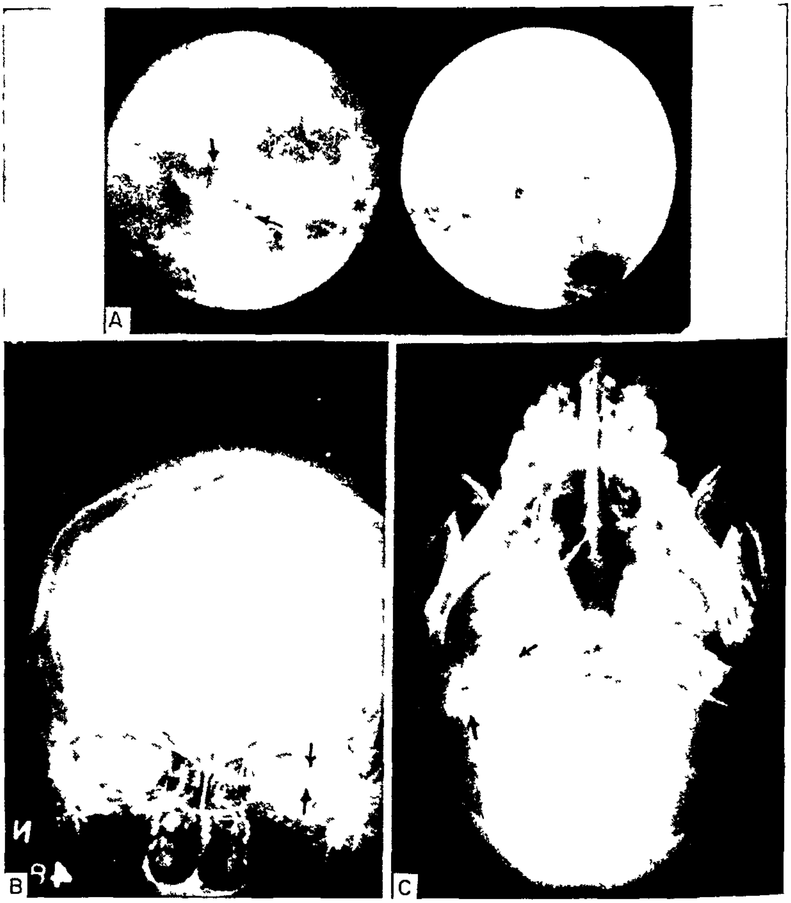

Fig 5 —A-B-C

NEUROFIBROMA

Duke History C 42898—C S V , age 13, a white boy, had a history of swelling behind his ear since the age of 4 or 5 months The swelling progressed very slowly until a history of mumps about five weeks prior to admission to Duke Hospital in 1948 Four weeks before admission he had had an acute swelling following an attack of mumps, and because of destruction around the left temporal bone it was decided that he had a destructive mastoiditis The mastoid was operated upon No pus was found, and a diagnosis of lymphangioma was made on biopsy These slides were unavailable for study

On examination at our hospital the patient had a well healed retroauricular incision The pinna seemed to detach from the bony skull The canal was filled with purulent discharge, and it was closed so that the drum could not be seen The consistency of the mass behind the ear which extended on into the parotid was doughy and rubbery, not unlike a sac of worms There was no bruit Roentgenograms showed a very smooth absence of bone around the inferior aspects of the mastoid and petrous apex on the left, findings being compatible with an extensive hemangioma

At operation, a doughy, stringy, beaded fibrous mass was found which pathologically proved to be neurofibroma His postoperative recovery was uneventful The follow-up to date has shown no increase in growth of this tumor mass, in spite of the fact that it was not all removed There was very little pain, very little otorrhea, and no hemorrhage from this ear

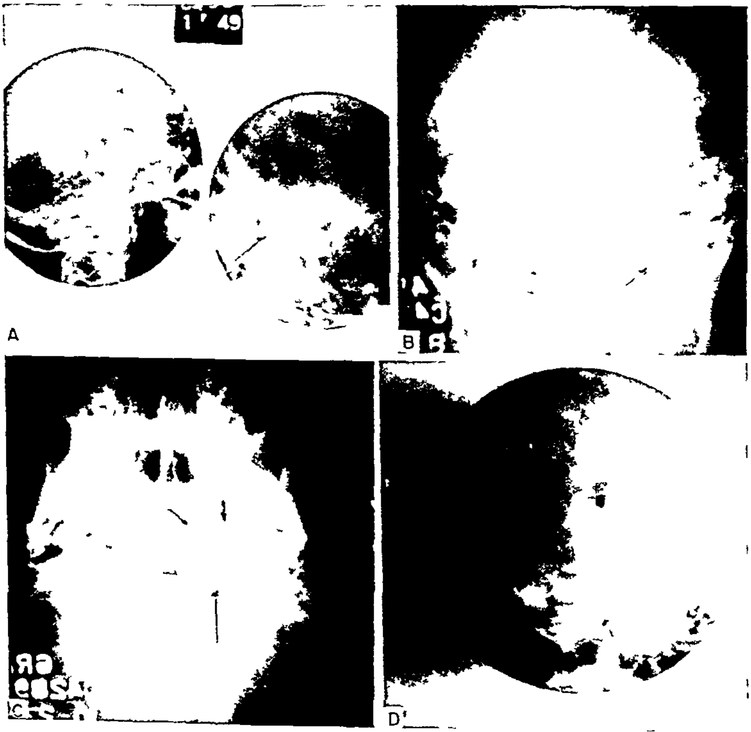

Fig 6—A-B-C-D

Clinically this lesion is progressive and very nearly asymptomatic until a cranial nerve becomes involved The patients are brought for evaluation, usually because of a deformity about the pinna which seems to have no bony attachment Roentgenograms reveal smooth pressure erosion with no bone reaction

Surgically we have been unable to extirpate this lesion because of its ramifications

ACOUSTIC NEUROMA

Duke History E-42989—E G A a 58 year old white male railroad worker

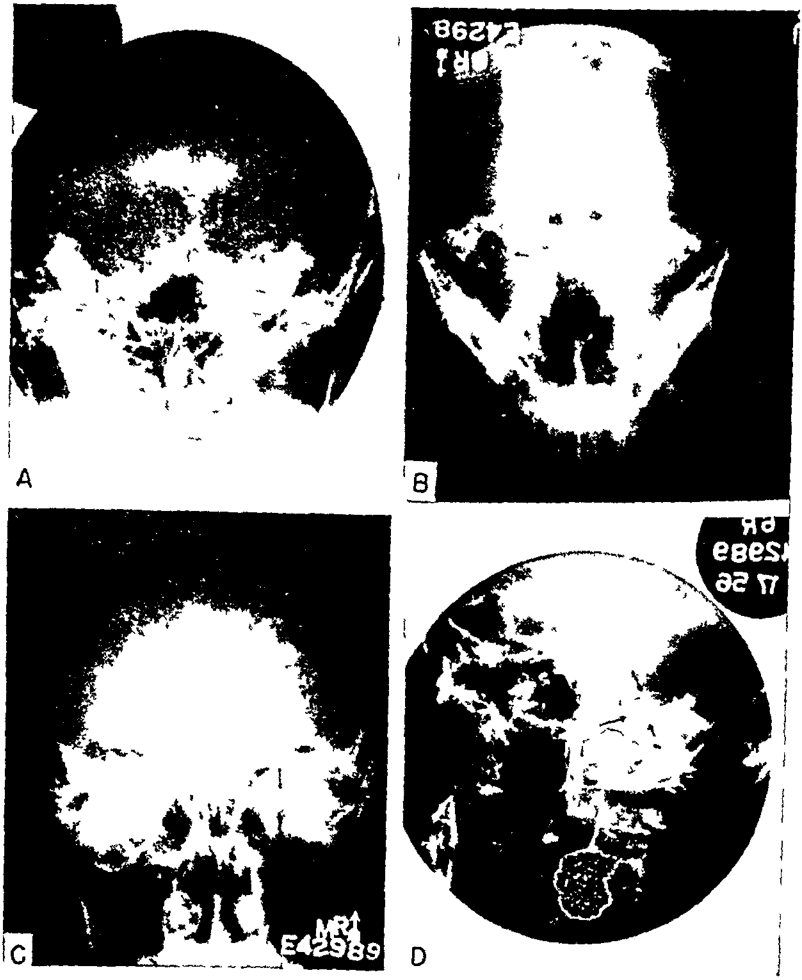

Fig 7—A-B-C-D

came into Duke Hospital on October 16 1956, with a history of headache, confusion and unsteadiness His headache was very severe for five or six days prior to admission There was no history of weakness in any of the extremities or any loss of consciousness He had some ataxia, the duration of which is not actually known Physical examination revealed BP 120/78, otherwise negative neurologically, including eye grounds There was no hearing on the right and an absent response to caloric stimulation on the right Physical examination was non contributory except for a spinal fluid pressure of 195 as an opening pressure His spinal fluid proteins were 150 mgm per cent

X rays revealed erosion and destruction of the right internal acoustic meatus in the mento vertex petrous apices and Stenver's views The neurosurgeons, through a right cerebellar approach found a right acoustic neuroma eroding the internal canal This was removed without undue difficulty His postoperative course was uneventful, except for the need of a tarsorrhaphy as he had a VIIth nerve paralysis as the result of cleaning out the internal acoustic meatus

This case could just as readily have been seen primarily by an otolaryngologist rather than by a neurosurgeon

CARCINOMA OF THE EXTERNAL AUDITORY CANAL AND MIDDLE EAR

Duke History A 36089—M M B, a white widow, age 64, had a history of otalgia, otorrhea, and swelling in and from her right ear of two years' duration prior to being seen at Duke Hospital Her system review was essentially negative The pain was worse at night The discharge at first was watery and later became thick and yellow There was apparently no bleeding from the external auditory canal, but she had had bleeding from her pharynx about three months before being seen at this hospital She also began to have trismus The right side of her nose became obstructed The examination was entirely limited to the right ear The canal was filled with bloody dark exudate, which came from a neoplasm in the external auditory canal, which bled readily The same type of tumor growth could be seen in the nasopharynx coming from the right eustachian tube and blocking the right posterior choana

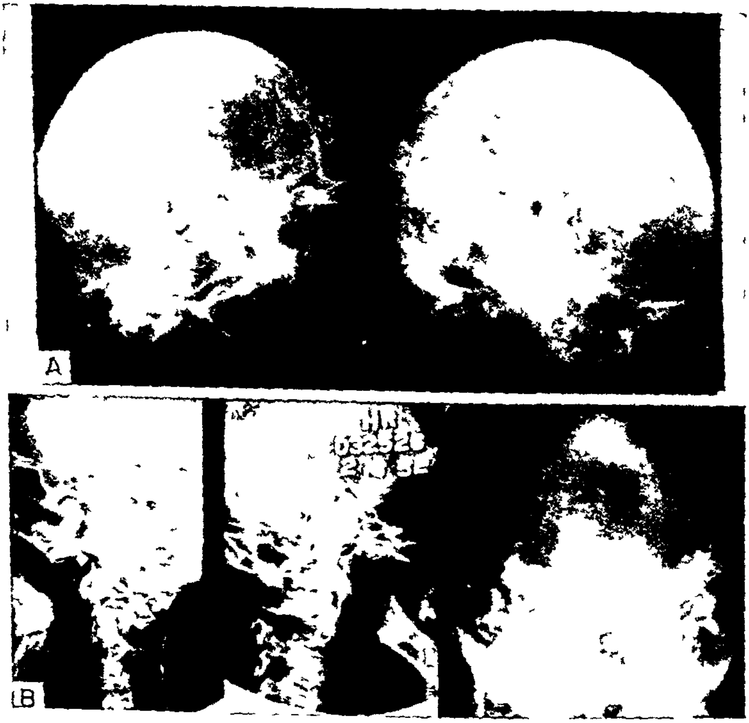

Fig 8—A-B

The tumor mass was biopsied and found to be squamous cell carcinoma Roentgenograms revealed destruction of all the cells in and around the mastoid This was probably the result of carcinoma and infection

The patient was treated with 7800 r of X-ray, and she was not seen again after the X ray therapy had been completed

This represents a case of carcinoma of the ear with destruction of part of the temporal bone extending down the eustachian tube The condition was obviously inoperable from the time she was seen, and it was hoped that X ray therapy might be a mode of treatment After 7800 r to the patient's tissues, the tumor continued to grow, and there is no doubt that she died from the lesion

LYMPHO EPITHELIOMA

Duke History A 150—B L, a white married woman, age 32, first presented herself at Duke Hospital with a history of otalgia and fluid in the middle ear The middle ear soon became purulent and revealed roentgenographic changes compatible with mastoiditis without cell destruction After symptoms of three weeks' duration a simple mastoidectomy was performed No growth on culture was obtained

The patient's pain persisted, her jaw became limited in motion, and exophthalmos occurred Mento vertex plates taken when these signs and symptoms were present revealed destruction of the petrous tip and basi occiput

A positive biopsy of lympho epithelioma was obtained from the naso pharynx, which readily accounted for all the patient's signs and symptoms

This patient presented a destructive invasive lesion of the nasopharynx which spread through the foramen lacerum, superior orbital fissure and obstructed the eustachian tube causing her ear symptoms

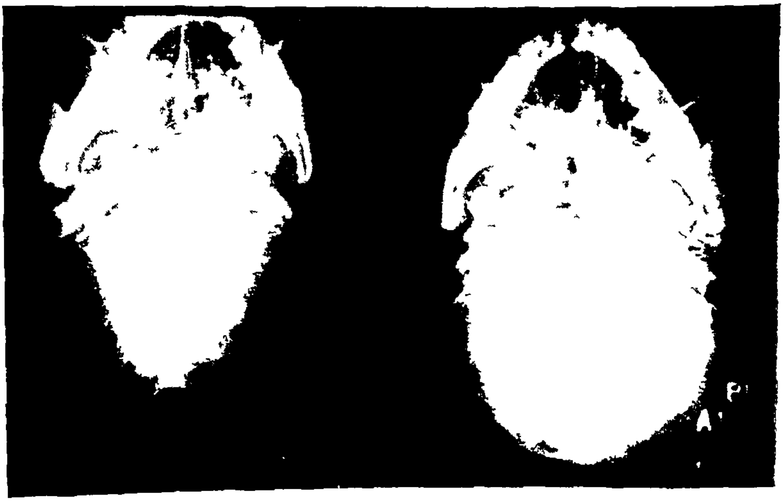

Fig 9

CYLINDROMA, NASOPHARYNX

Duke History C 56448—E B B , a white woman, age 48, was first seen at Duke Hospital with a history of pain in her right face which had been present for 18 months Examination revealed a tender mass with enlargement of the alveolar ridge on the right with bulging into the mouth The area was fluctuant, and on roentgenogram the lateral wall of the antrum and palate seemed to be gone We thought that we were dealing with carcinoma, and exploration revealed a hard, rubbery, doughy mass that extended into the antrum The pathologic diagnosis was cylindroma

This patient was followed from the Fall of 1949 Because of further extension of this tumor into the nasopharynx and erosion at the base of the skull, the patient was admitted on the neurosurgical service for section of V, IX, X cranial nerves and I II, III cervical nerves for pain relief

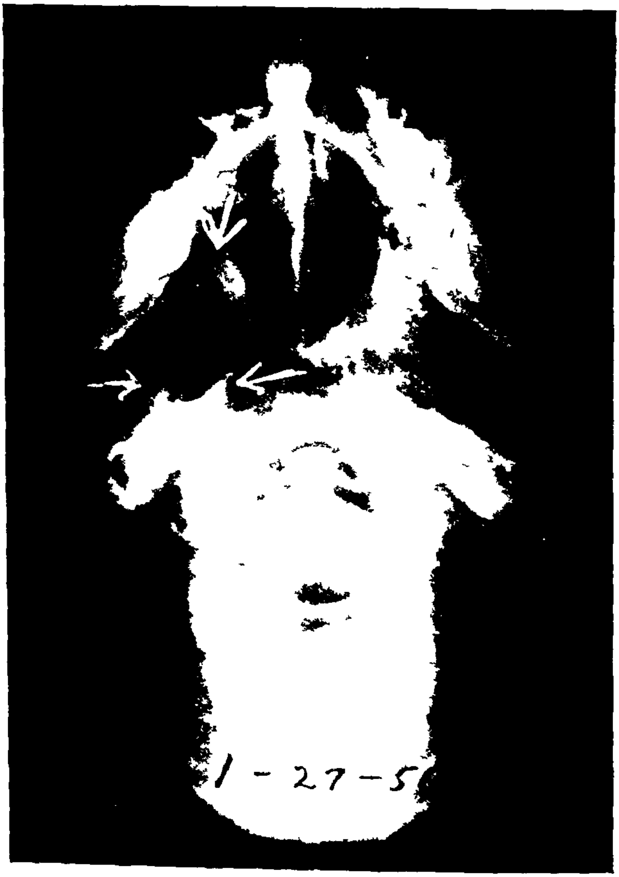

Fig 10

The patient died in April, 1950, from intracranial extension of the cylindroma

Roentgenograms taken in the mento vertex position showed destruction of the petrous tip along with basi occiput and portions of the sphenoid bone

This demonstrates a locally invasive tumor that is progressively invasive if not removed The petrous apex is destroyed by a contiguous destructive lesion

ANATOMICAL DEFECT OF THE TEMPORAL BONE

Duke History B-2594—E M P, a 37 year old white married woman, had a history of a grinding noise in her head of about four years' duration At times it remained constant and was synchronous with her heart beat and limited to the right side of her head, at other times it disappeared and there was no sound whatsoever She had been able to eliminate the sound by digital pressure over her carotid There had been no headaches, convulsions, sensory or motor disturbances

The examination was entirely negative with reference to her ears, nose, sinuses, and throat, neurologic examination was also negative Bruit was heard over the right ear with a stethoscope sometimes, at other times it could not be heard at all Roentgenographic examination showed a defect over the right sinal dural angle There was no abnormal vascular pattern in this area, and no change was seen over a period of four years The question of an arterio venous aneurysm was entertained, and hence an arteriogram was done, and this was found to be normal

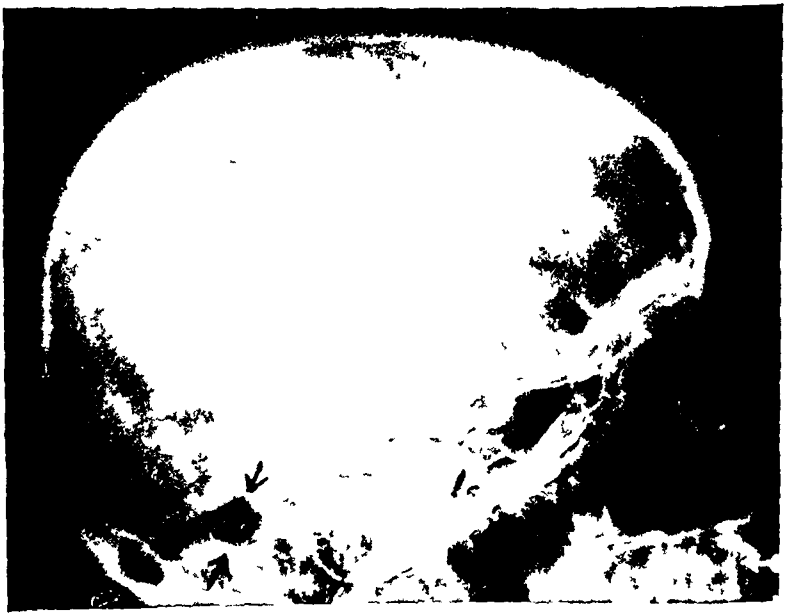

Fig 11

The patient was eventually explored. An acute bend in the lateral sinus was found and when this was released the tinnitus disappeared.

The only symptom was tinnitus and an apparent anatomical defect in the temporal bone was discovered by roentgenogram. Just why this patient had tinnitus from the lateral sinus or why it does not occur more often we do not know. We also do not know why it occurred intermittently.

IDIOPATHIC CHANGE

Duke History B 47314—K W S an 11 year-old white boy was first seen in 1945 at the age of 4 because of a history of meningitis for which he was hospitalized for a period of 26 days. This meningitis started with an acute infection in his right ear complicated by mastoiditis for which he had a simple mastoidectomy. Examination in 1945 revealed no positive physical findings except that there was questionable bone destruction in the right mastoid. The patient was again seen in July 1952 because of a facial paralysis that had appeared spontaneously without otorrhea otalgia or any other symptoms. Roentgenograms at this time revealed a lesion in the petrous apex questionable enlargement of the sella and destruction in and around the mastoid. Because of the complicating factors in this case an encephalogram was done which revealed no abnormality. The right mastoid was explored and a large mastoid cell with normal mucous membrane extending toward the jugular bulb and base of the skull was found. The facial nerve was lying uncovered with new bone formation pressing on it. The nerve was decompressed but it was decided not to explore this petrous apex as the hearing was good and the child was asymptomatic except for the paralysis.

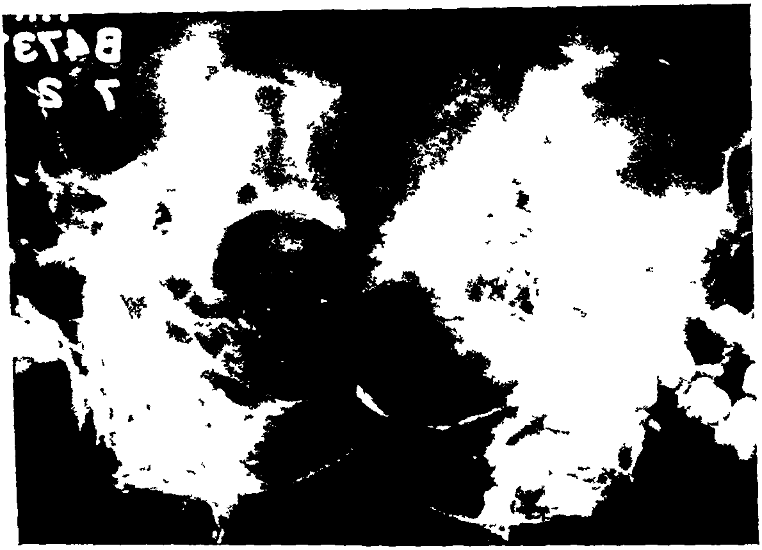

Fig 12-A.

The patient died in April, 1950, from intracranial extension of the cylindroma

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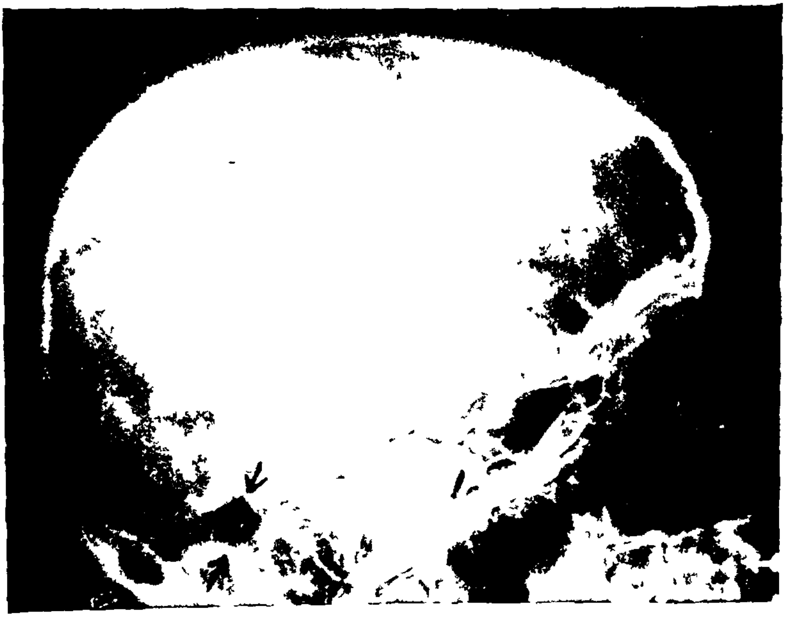

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The patient was eventually explored An acute bend in the lateral sinus was found and when this was released the tinnitus disappeared

The only symptom was tinnitus and an apparent anatomical defect in the temporal bone was discovered by roentgenogram Just why this patient had tinnitus from the lateral sinus, or why it does not occur more often we do not know We also do not know why it occurred intermittently

IDIOPATHIC CHANGE

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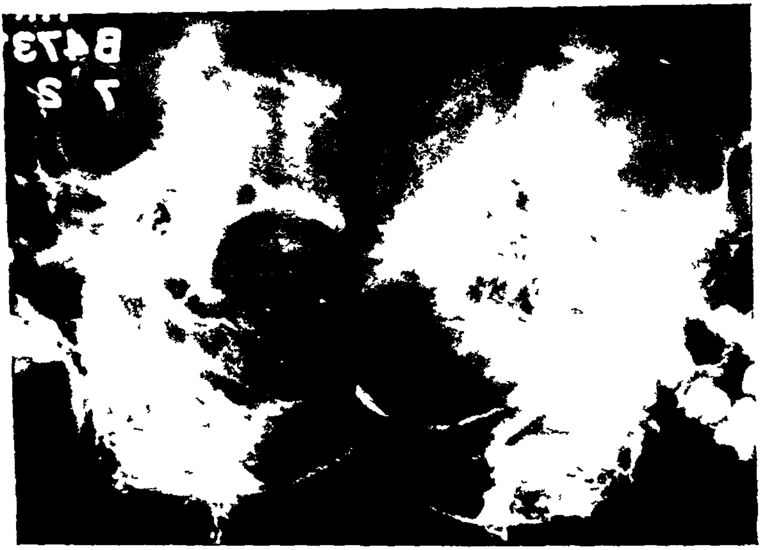

Fig 12-A.

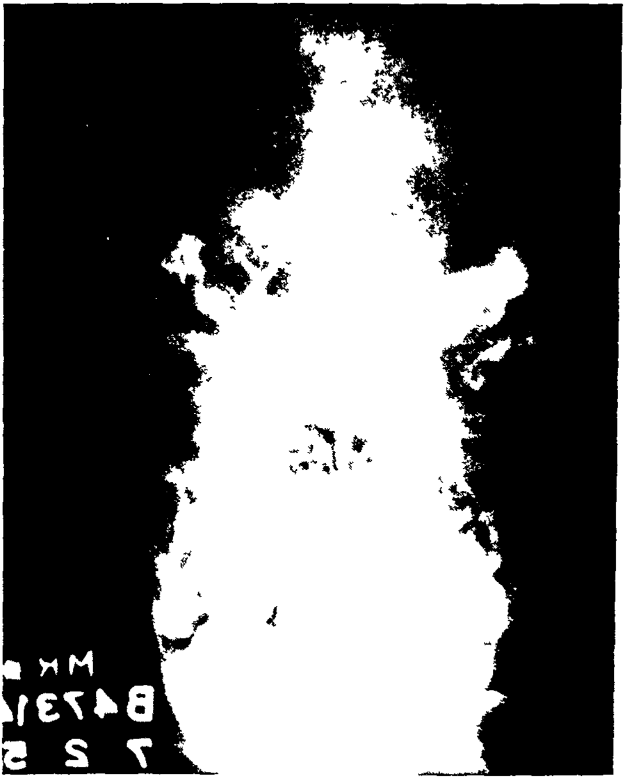

Fig 12-B

Just what this boy had, we have not the remotest idea We feel that his exploration at least advised us that there was no destructive lesion that is by tumor, and the decompression of the facial nerve has brought back a recovery of his facial function

MIDLINE CEREBELLAR TUMOR

Duke History A 7468—M O, an 18 year old white single woman presented herself at Duke Hospital with a long history of headaches which had become much worse in the preceding three months There had been no menstruation for a period of a year On examination the patient was found to have bilateral papilledema and hyperesthesia over all three branches of the right Vth cranial nerve There was a questionable right lower facial weakness The remainder of the neurological examination was negative Visual fields were normal Roentgenograms of the skull revealed increased convulsional markings with questionable widening of the sutures The right squamous temporalis area showed an area of destruction The dorsum sella was completely destroyed The patient had ventricular air injection which showed dilatation of the lateral and third ventricle The aqueduct was displaced upward and dilated The entire tentorium was pushed up The impression was that a sub tentorial tumor had occluded the fourth ventricle

The patient was explored, a midline cerebellar tumor was found that

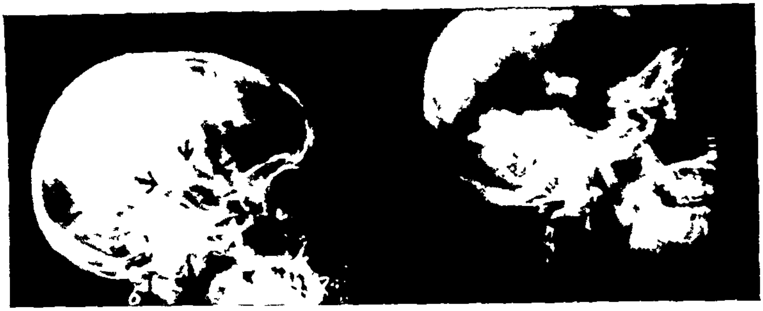

Fig 13

had occluded the fourth ventricle and the pathologic diagnosis was astrocytoma

This is another type of destruction of a portion of the temporal bone, namely the squamous portion due to increased intracranial pressure This falls into the realm of the neurosurgeon but we are including it in our series of cases, as she could just as well have gone to an ear nose and throat man with her headaches and received the same diagnosis

RHABDOMYOSARCOMA

Duke History E-68699—F G B, a 7-year old white female child had a

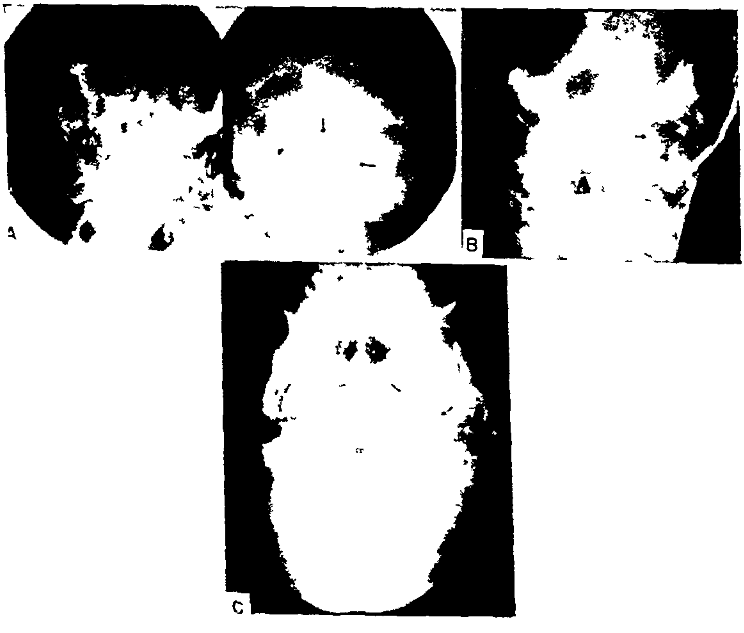

Fig 14—A-B-C

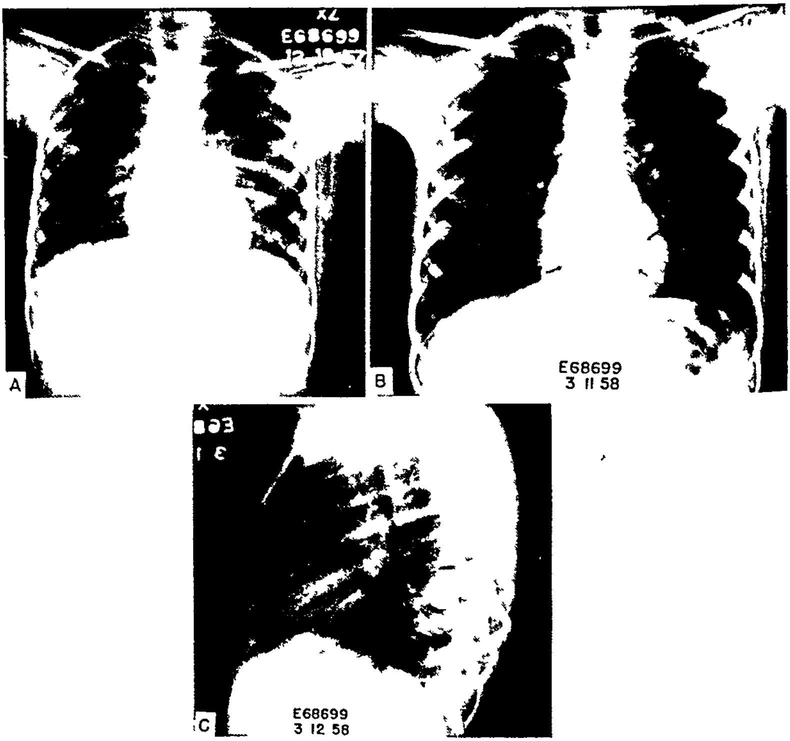

Fig 15—A-B-C

history of a polyp coming from her right ear for three months prior to December 21 1957 The polyp was removed, only to recur promptly On three different occasions that the polyp was removed, pathological examination stated it was chronic inflammatory tissue A radical mastoidectomy was done, only to have a prompt recurrence of this polyp like material in the external auditory canal and causing a breakdown of the retroauricular wound It was not until the fourth specimen of material was taken that a new diagnosis came back, which was myxoma The child was admitted to Duke Hospital on December 21, 1957 with this past history of operation and polyp recurrence

Examination revealed a beginning weakness of the right facial nerve, and two pedunculated hemorrhagic masses could be seen coming from behind her right ear They were about the size of a ripe fig Physical examination was entirely negative except for her right ear X rays revealed a well done radical mastoid cavity, but there was decalcification along the eustachian tube, the temporal mandibular fossa, and questionably along the foramen lacerum On the following day December 22 1957, an endaural incision was made, and a soft gelatinous mass was removed from the mastoid cavity, and all the bone covering the tegmen lateral sinus, dural sinal angle, cerebellum, anterior and inferior bony canal walls were removed The retroauricular incision was closed with interrupted sutures and plain gut A pressure dressing was put on The patient withstood the procedure well

This was followed by a series of X-ray with no local recurrences of this lesion seen Further study revealed it to be probably a rhabdomyosarcoma She had a clear chest plate on December 21, 1957, the day of admission, but on March 1, 1958, she was re-admitted to the hospital with metastases to the chest and spinal column She subsequently died six weeks later from this very malignant sarcoma Nitrogen mustards were also tried following X-ray, but this was to no avail

This represents a very destructive, rapidly growing lesion which had all the appearances of benignity under the microscope until rapid regrowth necessitated a more careful study and the tentatively correct diagnosis was arrived at

COMMENT

Despite the number of varied destructive lesions that are listed, most of them fall into a category that can be remedied surgically, by irradiation, or both, as the case may be Fortunately, primary tumors arising in the middle ear are extremely rare, as reported by Furstenberg[1] in 1924 He reported the second carcinoma at this time His literature review stated Newhart found only 34 cases of middle ear carcinoma prior to 1917 Gerber stated there is one middle ear cancer to 5000-10,000 of other ear disease Tod, quoting from the records of London Hospital, where more than 200,000 out-patient visits a year are recorded, encountered one case of middle ear cancer Fraser[2] in 1930 reported that among 646 cases of diseases of the external meatus seen between 1906 and 1929, there were only three cases of malignant disease (0 464 per cent) In the Royal Infirmary he found that among 6605 cases of the external ear and meatus there were 13 cases of malignant disease, that is 0 197 per cent

SUMMARY

1 A series of cases demonstrating destructive lesions of the temporal bone has been demonstrated

2 Diagnostic means of establishing a diagnosis have been outlined

3 There are no simple or routine means of establishing a diagnosis or prognosis of a destructive lesion of the temporal bone unless one has a tissue evaluation

4 The lesions may be (a) congenital, (b) inflammatory, or (c) neoplastic

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MODERN ASPECTS OF RHINOPLASTY[*]

C J HEINBERG, M D ,
(By Invitation),

Pensacola, Fla

For many years little attention was given by the otolaryngologists to any form of rhinoplasty They viewed this variety of plastic surgery with alarm and allowed the general plastic surgeons to enter a field which should have remained entirely within their specialty The rhinologist has the fundamental knowledge of the anatomy and physiology which is so necessary to restore altered appearances, correct deformities and to maintain proper function

Initially rhinoplasty was regarded only as cosmetic surgery Today, many otolaryngologists have accepted it as a means of also correcting disturbed nasal function The nose is subject to trauma because of its prominent position, and this has been one of the basic causes of the need for rhinoplasty Rhinologists have been forced to adopt the new and better methods of treatment of injuries resulting from automobile mishaps, athletic injuries, industrial accidents, and the many other types of nasal injuries

Because of the universal recognition of its psychologic, physiologic and esthetic significance, rhinoplasty has made much progress It is important to note that the term rhinoplasty, which is derived from the Greek Rhis, meaning nose, and Plassein, to form, is now used to embrace more than simple cosmetic nasal surgery Goldman[1] states that a change in the form of the nose or any component part constitutes a rhinoplasty

The term includes the categories of cosmetic rhinoplasty, which would combine the correction of external nasal deformities for treatment of the frustrated ego, and functional rhinoplasty for the alleviation of impaired nasal function

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[*] Read at the Meeting of the Southern Section of the American Laryngological Rhinological and Otological Society Atlanta Ga Jan 23 1959

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It is well-known that nasal deformities affect an individual's mental well-being and may result in social insecurity and economic hardship

It has been suggested that every candidate for cosmetic surgery be asked three questions

1 Do you sleep well?

2 Do you eat well? and

3 How many days are you absent from work?

If the patient cannot answer these questions satisfactorily, no surgery should be contemplated, and the individual should be referred to a psychiatrist for an evaluation In a psychiatric study of a series of cases, Linn and Goldman[2] state that with few exceptions, the patients who came for rhinoplasty were clearly ill from a psychiatric point of view The syndrome they discovered consisted of a constriction of the ego to the point where these persons believed that people looked down on them because of the shape of their noses Seeing their deformities mirrored each day, these people magnify what they view to the point where it becomes obsessive According to Schilder[3] each one of us has a mental image of his appearance When this is displeasing, the mental well-being of the individual is disturbed

It is quite amazing to observe the immediate reaction of one of these individuals to a well performed rhinoplasty There is a rapid reorganization of the patient's mental image of himself The inferiority feelings are replaced with feelings of self confidence Patients display new warmth, which is so marked that it is evident in their photographs Much could be said and written of the psychiatric aspects of rhinoplasty It is most important that the rhinologist recognize occasionally mentally disturbed patients before surgery and employ psychiatric advice It is these patients as a rule who cause the postoperative headaches for the surgeon, yet, on the other hand, they can be the most satisfied and grateful individuals when handled properly

It can be readily understood that in our competitive world of today personal appearance plays an important role in the success of the individual Persons who have nasal deformities find that these either detract from their economic advancement, or sometimes become their fortune when they capitalize an oddity, as did Jimmy Durante and W C Fields

FUNCTIONAL

The problem of nasal obstruction has consistently offered a challenge to the rhinologist Altered functions of breathing and eating cause patients to consult their physicians for relief from these distressing symptoms Secondary symptoms, such as dry and recurring sore throat, hearing deficiencies from insufficient aeration of the middle ear due to blocked breathing on the convex side of a severely deviated septum, hyperplastic rhinitis and other sequelae also are subjective complaints

Most of the nasal deformities involving the external nasal pyramid and/or the nasal septum are traumatic in origin They may be hereditary or developmental

Kirschner[4] states that injuries to the nose which cause deformities are found in the newborn They are

A Recent, occurring during birth,

B Prenatal, occurring as a result of forces applied to the nose during intrauterine life

During delivery the force of the motive power in the physiology of childbirth creates a pressure of almost 40 pounds This pressure, which is exerted on the nose during the passage of the infant through the birth canal, frequently causes a separation of the cartilaginous portion of the septum from the vomerian groove This can be easily replaced with the thumb and forefinger and requires no special training or instruments It is incumbent on all otolaryngologists to request obstetricians to inspect and palpate every infant's nose for septal dislocations, as a part of his routine examination, to determine the presence of nasal abnormalities and any other deformities of the new born

The prenatal injury is usually more extensive than birth canal injuries, as it usually involves the bony as well as the cartilaginous pyramid and septum. It results from intrauterine pressure pushing the nose against the mother's bony pelvis during intrauterine life Cottle and Kirschner[5] agree that instrumentation of these deformities is valueless and that the nose resumes a midline position, or markedly improves, before the infant reaches the age of 3 months

The nasal bones, lobular cartilages and septum, deserve very careful study in all cases of trauma This should include all forms of examination, such as inspection, intranasal examination, palpation, and X-ray films Only by these means can deformities and alteration of nasal physiology be discovered and latent effects be prevented

When fracture of the nasal pyramid occurs, it is important to correct any deformities for physiological as well as cosmetic reasons If the upper lateral cartilages are torn, it is necessary that they be repositioned and fixed in place Cottle[6] states that the ends of the lobular cartilages help as functioning structures of the nose, and that disharmony between the structures of the external nasal pyramid and the internal nose is a cause of nasal illness

Most nasal fractures occur in the lower thin portion of the nasal bones It requires a crushing blow to cause a fracture in the upper half, where the bone is thick and firm Simple fracture can be reduced easily with an elevator or manipulation with a forceps, such as the Walsham Open reduction is advocated and offers some advantages This is done by utilizing existing lacerations or by the usual rhinoplastic approach, and with the elevation of the dorsum fragments can be inspected directly, repositioned under direct vision and hematomas evacuated Better cosmetic, as well as physiologic results can be achieved This is particularly true if there is involvement of the septum

In cosmetic rhinoplasty, the patient seeks the physician, requesting the operation When there are nasal deformities resulting from injury, and the function can be improved by the procedure as well as appearance, the physician should not hesitate to recommend it[7] Rhinoplasty is the only procedure for the correction of deformities resulting from old and neglected fractures of the nasal bones Restoration of the nasal bones to proper position and realigning of the lobular cartilages can be done solely in this manner

SEPTAL INJURIES

Alteration of the nasal septum from the midline is a common sequella of nasal trauma As reported in a previous presentation,[8] it is my desire to classify septal injuries chronologically as

1 Prenatal,
2 Birth injuries,
3 Pre-adolescent injuries,
4 Post-adolescent injuries

New concepts of treatment make this classification important

As aforementioned, the prenatal injuries are caused by forces applied to the nose during intrauterine life, and no attempt is made to correct these for at least three months after birth

The birth injuries are simple cartilaginous displacements, and are replaced by either manual or instrumental manipulation of the cartilage back to the midline Formerly, pre-adolescent injuries to the nasal septum were problems If immediate replacement and packing in the midline did not correct and latent deflection occurred, the deformity was left alone until full development of the nose had taken place Most authorities agreed that the period of full nasal development is about 18 years of age Correction by submucous resection could not be done in these cases, as removal of tissue, as done in the classical surgical procedures of Metzenbaum, Killian or Freer, interfered with the growth and development of the nose by removal of the growth centers, which are supposedly located at the junction of the quadrilateral cartilage, the perpendicular plate of the ethmoid and the vomer Many surgical procedures were evolved, such as cross-hatching of the quadrilateral cartilage, in the effort to restore blocked nasal respiration to normal breathing Jennes[9] remarks that as the septum goes so goes the nose If the septum is twisted in a child the nose grows the same way.

When the septum is dislocated from the vomerian groove and caudal deviations ensue, not only is nasal respiration impaired, but facial development in the young, is hindered also For many years, physicians have recognized adenoid facies from nasal airway obstruction, but it is only lately that septal facies has been regarded as a definite entity

In the developmental process, the external face muscles serve to lengthen the facial skeleton, and the tongue muscles spread the facial structures laterally Goldman[10] recognized that when the caudal end of the septum was deviated in children the apposition of these muscles was interfered with, and other deformities resulted These post-adolescence deformities were resultant from trauma in pre-adolescence He proposed a term[9] "Maxillofacial Triad" to designate the disfigurements of

1 Crooked nose—caused by caudal septal deflection,

2 Gothic arch of the palate—dental deformities—Malocclusion,

3 Chin deformities—Microgenia—Micronathia

Salinger[11] relates that much has been written and said about the septum in recent years Older procedures have been subjected to modifications, and new methods advocated It is quite apparent, therefore, that surgery of the septum is not as simple as it seemed to be in the days when we had only the submucous resection, and before the present era of the enthusiasm for rhinoplasty This is true, and very fortunate In his enthusiasm for rhinoplasty, Goldman[12] devised a septal technique which lends itself to surgery on the septum of the child This operation is a combination of rhinoplastic and septal surgical procedures The dorsum of the nose is uncovered, as in classic rhinoplasty, and transfixion of the septum is done The septum is thus mobilized and submucous elevation of the mucous membrane, mucoperichondrium and mucoperiostium is accomplished from the caudal end of the septum[11] The septal (quadrilateral) cartilage is incised vertically, creating two caudal vertical segments, which are freed at the base by incisions along the nasal spine and maxillary crest, thus breaking the spring of the cartilage Posterior bony deviations are replaced in the midline by fracturing, if they are present[17] The caudal segmented portion of the septum is then sandwiched together by mattress sutures, and septocolumellar sutures reattach the septum to the columella Light packing with vaseline gauze, and external rhinoplastic dressings are applied Thus the septum is replaced in the midline with no removal of tissue and no interference with growth centers[18] It is a prophylactic procedure in the prevention of the maxillofacial triad, and restores normal nasal physiology This technique is also used in surgery of the septum in adults with more acceptance by the patient, and less chance of saddle nose, dropped tip deformities, and columella retraction, which are seen as sequelae to other types of procedures, therefore, any deformity, injury or disease of the nose, should become the responsibility of the rhinologist,[13] it is he who is dedicated to the prevention and treatment of nasal diseases In rhinoplasty, the otolaryngologic surgeon has a very valuable addition to his armamentarium

COMMENT

Just as the speedy jet planes have superseded the early aeroplane of the Wright Brothers, and atomic weapons have replaced the musket, so have new innovations been added to the armamentarium of otolaryngology

New concepts of the management of nasal injuries and deformities have been presented with special reference to psychiatric aspects, and the correction of nasal pathology in children, to restore normal physiology and prevent post-adolescent sequellae

It is emphasized that the rhinologist is the more competent specialist to diagnose and manage nasal injuries

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THE OTOLARYNGOLOGIC ASPECTS OF SKIN AND SCUBA DIVING*

G DEKLE TAYLOR, M D ,

Jacksonville, Fla

"Man is essentially a terrestrial being, and his anatomy and physiology are not modified for a water environment When man is out of his normal sphere, he must understand what limitations nature has placed on him and not ignore the fundamental laws that regulate his own being"

This observation was made by Taylor[1] in 1939, and for many years stimulated his study of biology and comparative physiology as related to otolaryngology Though man lacks appropriate adaptation to an aquatic environment, he has found other means of protecting himself in such an environment Taylor[2,3] demonstrated that man has adapted himself to surface swimming by proper methods of breathing which protect his respiratory epithelium from the ill effects of water, and later Taylor and Dyrenforth[3,4] reported research which established that the prevention of chilling with its associated lowered resistance and subsequent infection is possible through time limitations and exercise in the water

In recent years, man has become restless with his surface existence and through his ingenious ways has devised methods of exploring the fascinating worlds of the atmosphere above and the sea below His ultimate future in these two environments will probably far exceed the concepts of the keenest

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*Read at the Meeting of the Southern Section of the American Laryngological Rhinological and Otological Society Atlanta Ga Jan 22 1959

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imaginative minds of today The modern physician must assist his fellow man in these endeavors and familiarize himself with the physics and physiology of the subaquatic and space environments The military physician has made a great contribution in this field, and without his understanding and guidance man's progress in these two realms would be very limited

Sports diving has today become a recreation for millions of people throughout the world The underwater diver, equipped with the snorkel (underwater breathing tube), face mask, and flippers is commonly known as a skin diver The time and depth of his underwater explorations are dependent upon the length of time he is able to hold his breath In 1944, a French naval officer, Capt Jacques-Yves Cousteau, and a French engineer, Emile Gagnan, designed the Aqua-Lung This device consists of a tank or tanks containing air under pressure which delivers the air through a tube and mouthpiece to the swimmer at a pressure comparable to that of the aquatic depth he has attained The equipment is commonly known as self-contained underwater breathing apparatus, conventionally shortened to the term "scuba" The duration of the underwater period and the aquatic depth the diver attains with this equipment are limited only by the physiology and physics which govern his being and the amount of air in the tank In addition to protecting his respiratory tract from the water and preventing body chilling, he must now adapt himself to the effect of the pressure exerted on his body by the subaquatic environment

Every physician should know the medical problems and dangers inherent in skin and scuba diving This knowledge is of the essence to the physician who resides near water which attracts the curious of all ages There are avid enthusiasts in every state in the Union Wherever there is an old water-filled quarry of sufficient depth to invite curiosity, there will probably also be a group of these divers

Many of the medical problems involved are related to the specialty of otolaryngology Otolaryngologists should be cognizant of these problems, both from the standpoint of prevention and of treatment They should be prepared to offer advice as to the physical requirements for this sport and should discourage those persons from diving who are not physically or mentally fitted to engage in it.

DIVING PHYSICS

For practical purposes water is incompressible. Air is easily compressible, and changes in volume resulting from small changes in pressure are readily observed. Atmospheric pressure is due to the weight of air just as water pressure is due to the weight of water. An immersed body is subjected to the sum of the atmospheric and water pressures. This value is known as absolute pressure. Atmospheric pressure at sea level is the weight of a column of air one square inch cross section having a length extending in the vertical direction as far as the atmosphere extends. This measured pressure is approximately 14.7 pounds per square inch, and it is called a pressure of one atmosphere.

Depth in Feet	Atmospheres	Pounds Per Square Inch
0	1	15
33	2	30
66	3	45
99	4	60

One atmosphere of pressure at sea level is equivalent to a one inch square column of water 33 feet high and beneath the surface. Every foot of depth of sea water produces a pressure of 0.445 pounds per square inch, and every 33 feet of sea water exerts a pressure equivalent to one atmosphere of pressure. The atmosphere above the surface is also exerting a pressure of 14.7 pounds per square inch.

According to Boyle's law, the volume of a body of gas varies inversely to the pressure to which it is subjected if the temperature remains constant. The density, however, varies directly. Fig. 1 illustrates the effect of pressure on the lung of the skin diver and Fig. 2 demonstrates the equalization of pressure on the scuba diver.

Since the human body is composed mostly of solids and

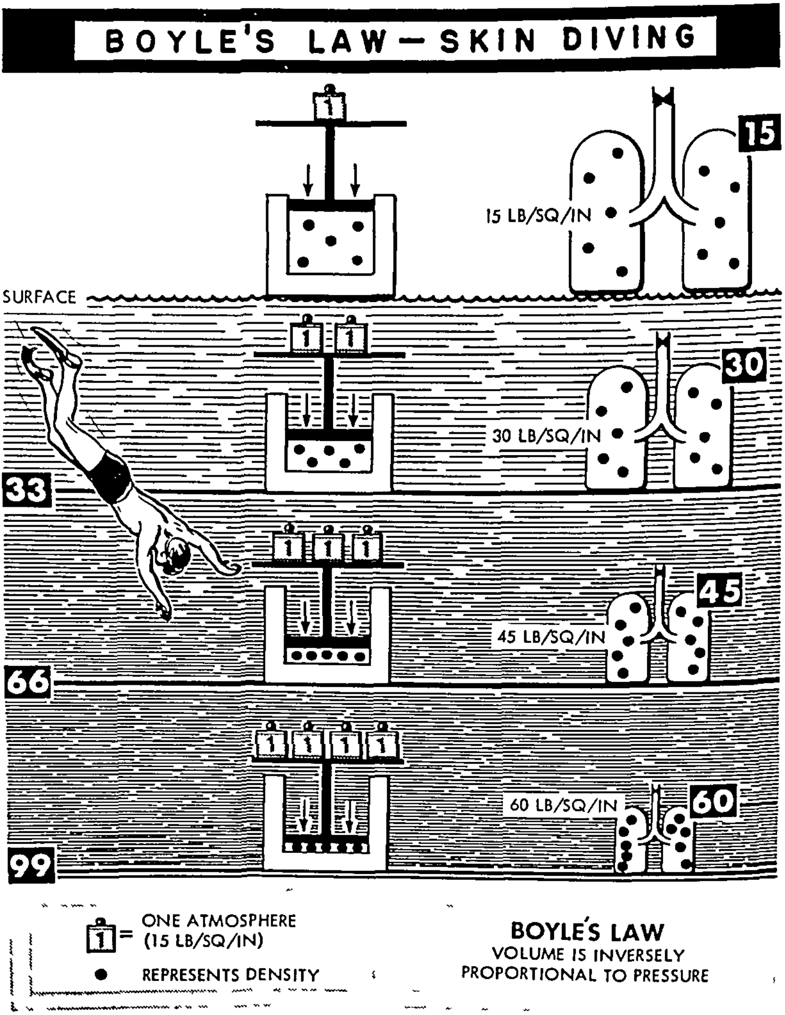

Fig 1 Boyle's Law—Skin Diving Pressure changes occurring in the lung of the skin diver with the glottis closed The lung is compressed by the external ambient pressure

A At 33 feet (2 atmospheres absolute pressure) the pressure is doubled and the volume is half

B At 66 feet (3 atmospheres of pressure) the volume is one-third and the pressure tripled

C At 99 feet (4 atmospheres) the volume is one-fourth and the pressure is increased four times

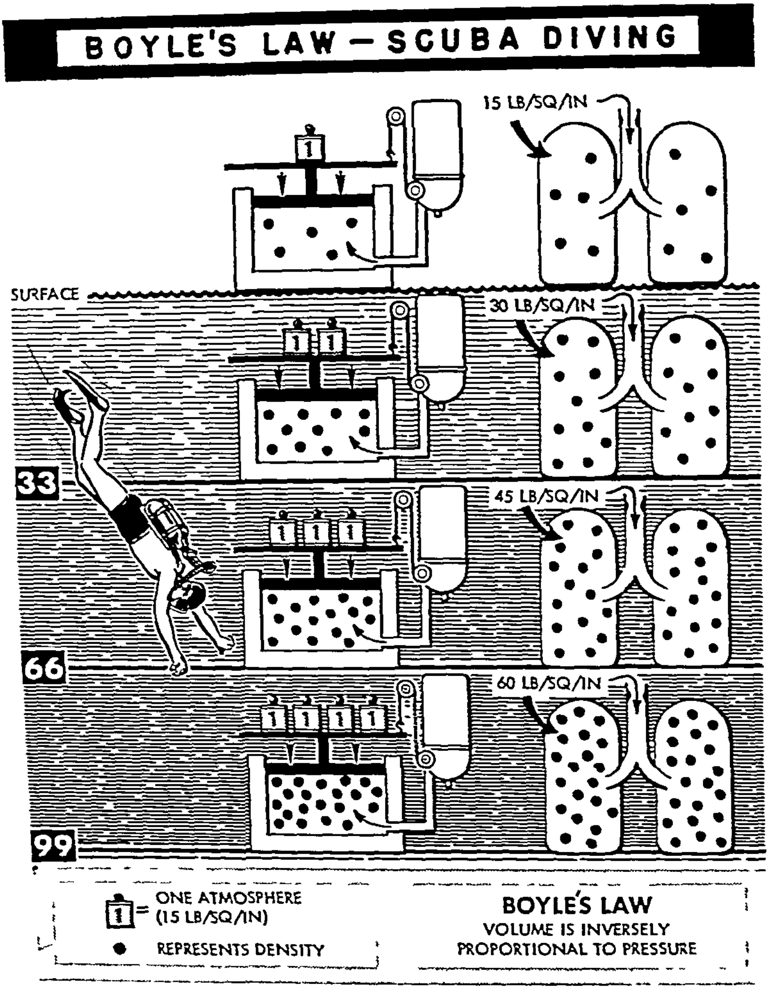
BOYLE'S LAW — SCUBA DIVING
15 LB/SQ/IN
30 LB/SQ/IN
45 LB/SQ/IN
60 LB/SQ/IN
SURFACE
33
66
99
1
= ONE ATMOSPHERE (15 LB/SQ/IN)
● REPRESENTS DENSITY
BOYLE'S LAW
VOLUME IS INVERSELY PROPORTIONAL TO PRESSURE

Fig 2 Boyle's Law—Scuba Diving The scuba delivers air through the open glottis to the lung at a pressure that varies with the ambient pressure

A At 33 feet (2 atmospheres absolute pressure) the lung volume remains the same Pressure and density are doubled

B At 66 feet (3 atmospheres) the lung volume remains the same Pressure and density are tripled

C At 99 feet (4 atmospheres) the lung volume remains the same Pressure and density are increased four times fluids, it is able to withstand increased pressure well Behnke,[5] in 1944, observed that the remarkable phenomenon of adaptation to environmental stress is exemplified by man's tolerance to rapid and extreme alterations in barometric pressure "If pressure alone is considered," he stated, "apart from the effect of gases in the viscera, in the aural and sinal spaces and in solution in tissues, then variations in pressure in the range of 0 11 atmospheres (50,000 altitude) to 16 1 atmospheres (500 feet diving depth) are without physiologic effect" Pressure differentials developing from localized inability to transmit the increased pressure lead to pain and disease in the skin and scuba diver This effect takes place mainly in the middle ear and sinuses The scope of this paper is limited to the problems of the ears and sinuses and the relationship of the larynx to the development of air embolism, pneumothorax and mediastinal emphysema The numerous problems of diving as related to the effects of the partial pressures, and solution and evolution of gases are not included

OTOLARYNGOLOGIC PROBLEMS

Pressure Factors

The normal ear maintains a pressure equal to that of the immediate environment The eustachian tube provides the only means of equalizing the air pressure in the middle ear to the changing pressures of ascent and descent The main function of this tube is to ventilate and drain the middle ear Its pharyngeal ostium is normally closed except when opened by positive pressure in the nasopharynx or muscular activation by the tensor veli palatini, levator palati and salpingopharyngeus muscles The nasopharyngeal ostium of the tube acts as a valve which is normally closed The respiratory ciliated epithelium beats downward toward the nasopharynx A positive pressure in the middle ear opens the eustachian tube with little difficulty, as occurs in ascent

Armstrong and Heim[3] demonstrated that in descent the eustachian tube acts as a flutter valve and remains closed under all degrees of pressure unless it is opened by voluntary action One subject tested to a pressure of minus 470 mm of mercury suffered a tympanic perforation These authors showed that voluntary opening of the tube will immediately equalize pressure completely. When a negative pressure of from 80 to 90 mm of mercury or more had developed in the tympanic cavity, it was impossible to open the tube voluntarily This degree of negative pressure held the fibrocartilaginous portion of the eustachian tube collapsed The atmospheric pressure then had to be decreased before the tube could be voluntarily opened

Aero-otitis Media

A pressure differential between the air of the middle ear and the external environment sets up a pathological state in the middle ear Armstrong and Heim[3] designated this condition aero-otitis media and stated that it commonly occurs during change of altitude in airplane flights It is characterized by congestion, inflammation, discomfort, and pain in the middle ear, and there may be tinnitus, vertigo and temporary or permanent impairment of hearing Bleeding may occur in severe cases The pathological changes may, in fact, vary from slight congestion to extensive rupture of tissue Aero-otitis media is probably the most common pathological condition resulting from flying and skin and scuba diving

In the person with a widely patent eustachian tube aero-otitis media would not develop on ascent or descent as there would be a free flow of air between the middle ear and the nasopharynx Any condition which enhances the narrowing of the tube increases the likelihood of aero-otitis media's developing

The degree of pathologic change caused by otitic barotrauma varies with the amount of pressure differential between the middle ear and the ambient pressure, and the length of time before the pressures are equalized The tissue changes are due to a suction effect, the mechanism of which might be compared to that which occurs when the suction bulb is put on the arm in the capillary fragility test[15] In the mild case of barotrauma there is a slight retraction of the tympanic membrane and a dilatation of the malleolar vessels and the vessels in Shrapnell's membrane The vessels in the middle ear also expand, and the negative pressure causes them to become more dilated and engorged In prolonged and severe barotrauma there is an increased engorgement of these vessels and more pronounced retraction of the tympanic membrane

Small subepithelial hemorrhages may occur in the tympanic membrane The mucous membrane of the middle ear becomes congested and swollen The eustachian tube becomes increasingly swollen and blocked and frequently closes off the tympanic cavity Absorption of air by the vessels in the middle ear enhances the vacuum, and an increasing engorgement of the vessels and edema of the membrane follow A transudate of serous and serosanguineous fluid forms If the negative pressure is sufficient, there may be a rupture of

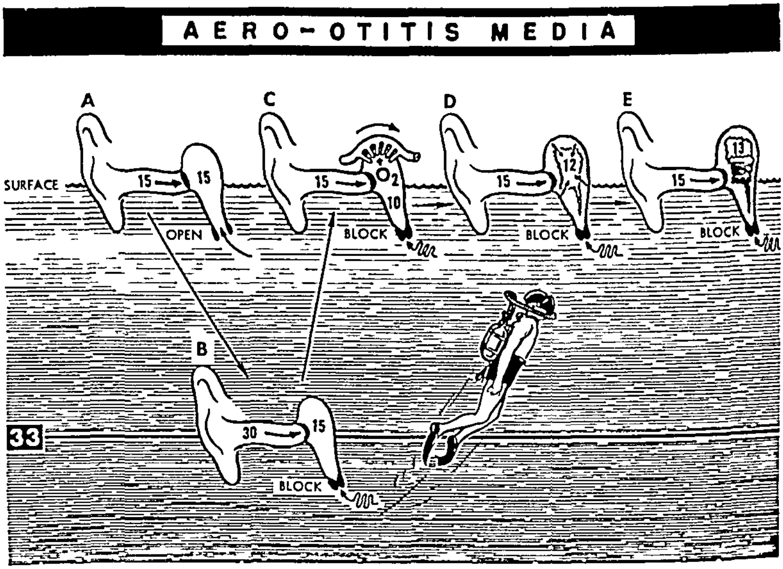

Fig 3 Aero-otitis Media

A The eustachian tube is open The ambient and middle ear pressures are equal

B With descent the pressure differential causes barotrauma and the eustachian tube becomes blocked

C The eustachian tube remains blocked as the diver ascends because of pain The negative pressure in the middle ear is increased at the surface by absorption of oxygen from the middle ear

D Edema of the mucous membranes and decreased volume of the middle ear Decrease in volume leads to decrease in negative pressure

E Serosanguineous fluid forms in the middle ear and decreases the volume of the middle ear further Decrease of volume tends to decrease in negative pressure vessels in the middle ear and the cavity fills with blood Sufficient fluid forms to equalize the ambient pressure In very severe barotrauma a rupture of the tympanic membrane occurs (see Fig 3)

Aero-otitis Media and Hearing Loss

Excellent studies have been carried out by the Navy and other military services to determine the relationship between barotrauma and hearing Some of the most thorough studies have been made at the submarine escape training tank at the U S Naval Submarine Base in New London, Conn Candidates for the submarine service are subjected to 50 pounds of increased air pressure in a recompression chamber prior to entering the water for actual training with the submarine escape appliance As pressure is increased in the recompression chamber, an inequality of pressure from the two sides of the tympanic membrane is created because of the restricted flow of air through the narrow eustachian tube The majority of men are able to equalize the pressure in the middle ear as pressure is increased through swallowing, yawning, or Valsalva's maneuver In some cases no maneuver is effective in bringing about the equalization of pressure, and if the pressure is increased, aero-otitis media develops

Etiological factors, mentioned by Armstrong and Heim,[3] which may prevent ventilation of the eustachian tube under pressure were recurrent acute respiratory infections causing blockage due to an inflammation of the mucosa and lymphoid tissue in the tube, nasal obstruction, sinusitis, tonsillitis, tumors of the nose and nasopharynx, paralysis of the soft palate or superior pharyngeal muscles, enlargement of the pharyngeal or tubal tonsil, inflammatory conditions of the eustachian tube or middle ear, and scar tissue about the ostium of the eustachian tube If the tube is blocked, the increase in pressure must be stopped or there will develop a sharp pain in the ear and damage to the tympanic membrane or middle ear

In addition to the etiological factors listed by these authors, one must consider anatomical narrowing of the eustachian tube In my case, reported herein, most of the difficulty was in the right ear Examination of the nasopharynx revealed no difference on the two sides One of the divers in my series was able to dive 80 feet, by skin diving, without difficulty with his ears He had no trouble in equalizing pressure unless he had a severe cold On examination, it was possible to see him move the tympanic membrane back and forth by merely breathing in and out through the nose Great variation in the ability to ventilate the tube may in such instances be due to the anatomical factor of a rather wide tube in one and a very narrow tube in the other Another diver was able to move the tympanic membranes back and forth by the to-and-fro movement of the jaws This effect suggests that malocclusion might have some bearing on the ability to equalize pressure in the eustachian tube

In a study by Schilling and Everley,[50] 152 of 2,751 men subjected to 50 pounds of pressure in a recompression chamber experienced aural symptoms so severe that they had to be decompressed and removed from the pressure chamber, usually before the pressure reached 10 pounds The most frequent and the most serious complication of aero-otitis media was the associated loss of auditory acuity, which was at times sufficiently great to be disabling In favorable cases it took a month for the hearing to clear, and in some cases it did not return to normal The hearing loss was of the conductive type As to therapy, these authors concluded that time was the only treatment available since it was necessary to await the organization and final absorption of the blood and serum in both the tympanic membrane and the inner ear In addition, they used ear drops and ephedrine nasal spray They believed that permanent damage to hearing, particularly in the higher frequencies, may result in any ear in which damage to the middle ear has been extensive They also concluded that taking of pressure is not the cause of loss of auditory acuity, but that the loss is associated with damage to the middle ear, caused by inability to equalize the air pressure They regarded compressed air illness as a rare cause of loss of auditory acuity

Teed's classification of the otoscopic findings after pressure tests has been widely accepted Grade 0, a normal-appearing tympanic membrane, grade I, a retraction of the tympanic membrane with redness in Shrapnell's membrane and along the manubrium, grade II, a retraction with reddening of the entire tympanic membrane, grade III, the same as grade II except that fluid is present in the middle ear, and grade IV, hemotympanum or perforation of the tympanic membrane, or both. Teed[55] reported that in his studies hearing loss was encountered in all grades except 0. In grades I and II hearing was restored within a few hours, but in grades III and IV, weeks or even months were required for recovery. In a few cases the hearing loss was permanent.

Teed[55, 56] noted that the longer a man stayed under pressure after pain began, the higher was the grade of aural damage. Those who were able to equalize up to 12 or more pounds of pressure and then experienced pain were, in general, found to have stopped equalizing and after noting pain, were no longer able to equalize the pressure.

Relief from tubal obstruction should not be expected as a results of tonsillectomy or submucous resection, in Teed's opinion. Spontaneous recovery of damage to the ears was the rule in the large series studied. This author observed that grade III ears, if not cleared in a week, may need a myringotomy.[55] He advised against ear drops and stated that nothing should be placed in the ear with a perforated tympanic membrane. His conclusion was that only adenoid tissue in the tube, upper respiratory infection, and possibly allergy are important as etiologic factors in the causation of obstruction of the eustachian tube. He observed that contrary to the belief that repeated autoinflation in the presence of an upper respiratory infection would cause otitis media, this disease developed from this cause in only one of 30,000 men, many of whom had acute upper respiratory infection at the time of the study. In his opinion, the otitis media probably results from pressure changes associated with tubal obstruction and not from autoinflation. Hearing loss depends on the degree and duration of the pressure differential and the degree of pathologic change sustained secondary to the barotrauma.

Haines and Harris[21] evaluated the responses of 6,149 men at 50 pounds of pressure (3.4 atmospheres) for from three to ten minutes Of this number, 26 9 per cent contracted aero-otitis media They observed that a feeling of fullness or congestion in the ear following pressure may be confused with loss of hearing Many of the men in their series with this complaint had normal audiograms They noted almost no effect on auditory acuity after exposure to pressure except for middle ears filled with blood unmixed with air, and concluded that the deafness was a result of dampening of the ossicles by the fluid in the middle ear This type of ear they classified as grade V, adding one category to Teed's classification, the only difference from grade IV in that classification being the presence of free serosanguineous fluid without entrapped air For the four types of ears classified by Teed[11] they noted little change in the acuity of hearing

Their studies indicated that the patient having difficulty equalizing eustachian tubes under pressure will continue to do so unless some mechanical alteration takes place in the mechanism of the eustachian tube The local use of Neo-Synephrine was of little value in their series, and no improvement resulted from psychotherapy Ninety per cent of the patients treated with radium to reduce the size of the hyperplastic lymphoid tissue in or about the tube became able to sustain pressure without aero-otitis media's developing Dental treatment was also undertaken to realign muscles to the eustachian tube by alleviating improper motion of the jaw

These authors observed that in a good percentage of the men in their series aero-otitis media developed for no obvious reason when they were under pressure They believed improper inflation was responsible because the men, although capable of autoinflation, would let the increasing pressure "get ahead" of them one or more times and then would inflate the ears only after some damage had been done

In evaluating the effect of barometric pressure changes on hearing, Kos[29] concluded that aviators may have repeated attacks of aero-otitis media without sustaining a permanent loss of hearing He believed that few Air Force combat personnel suffer aural disability as a result of pressure differentials associated with flying

The use of irradiation to the nasopharynx is being advocated for those having repeated bouts of aero-otitis media as a result of engaging in diving either as a vocation or an avocation Duffner[15] recently proposed that the monel metal radium applicator containing 50 mg of radium be applied three to eight times to the pharyngeal orifice of each eustachian tube for a period of eight to ten minutes at intervals of two weeks to one month In my opinion, radium should not be applied to the nasopharynx without a full understanding of its potential dangers The patient should be advised of the inherent and unknown dangers of this therapy. Otolaryngologists should not take lightly the admonition of Lampe[30] "On the basis of the known biologic effect of Beta radiation, the available data on the magnitude of the doses (as expressed in Roentgens) which are currently used, and the knowledge that the approved technique of repeated irradiation enhances radiation damage, the conclusion appears inescapable that permanent and significant radiation damage to the nasopharyngeal soft tissue is being produced not infrequently This being the case, one can anticipate encouraging an unpredictable incidence of the clinical manifestations of late radiation complications at some future time which may vary from a few to many years after treatment" I would not advise the use of the radium applicator for a sports diver, instead, I would advise that he seek another avocation Should I recommend it to the professional diver, I would inform him of its potential dangers

Two cases involving impairment of hearing as an occupational hazard associated with diving are presented

Case 1 In March 1958 I examined F McC, a 36-year-old man who had been employed as a diver for 12 years at Marine Studios Marineland, Fla He complained of a hearing loss of eight weeks duration Wearing a rubberized canvas suit the divers at Marine Studios dive in a circular tank 12 feet deep and a rectangular tank from 12 to 18 feet in depth They wear a helmet weighing approximately 80 pounds, which delivers 25 pounds of compressed air to the diver throughout the dive The diver usually opens the eustachian tubes by swallowing or movement of the jaws If necessary he may put his hand up under the helmet hold his nose and carry out a Valsalva procedure The duties of this patient required that he dive five or six times throughout the day to clean the tanks and feed the fish during the various shows There was a history of pain in the ears three or four years previously while he was diving in 18 feet of water experienced usually when he had an upper respiratory infection and associated particularly with the late afternoon dive

Eight weeks prior to consulting me, he had a prolonged upper respiratory infection, but continued to dive. Minor epistaxis after each dive was followed by intermittent bleeding from the left nostril for several days. While diving, he experienced severe pain in the left ear. On ascent from the tank, he experienced dizziness and noted a loss of hearing which had persisted in this ear, associated with a feeling of fullness, intermittent pain and tinnitus.

On examination, both tympanic membranes were slightly retracted, the reaction to the Rinné test was positive bilaterally, and the Weber test lateralized to the right ear. The tonsils were of moderate size, there was no excess of lymphoid tissue in the nasopharynx, the fossa of Rosenmueller was clear bilaterally, and a caloric test indicated normal vestibular function bilaterally. The audiogram showed

	128	250	500	1000	2000	1000	8000
Right	20	10	15	25	20	25	15
Left	65	80	75	75	80	85	75

There had been no pre-employment audiogram. The patient had been a wartime instructor in the Air Force Tactical Training Command, but he denied any exposure to loud noises. On several subsequent examinations, there has been no change in the hearing. Both ears were inflated without difficulty, but the feeling of fullness in the left ear persists. I advised him to stop diving.

Comment. It is difficult to conceive of the degree of pressure change to which this patient was subjected causing a nerve deafness of the degree indicated by the audiogram. The lack of other evidence made it necessary for me to conclude that he sustained the deafness secondary to his diving activities. This case illustrates the value of pre-employment hearing tests in industry. Haines and Harris[21] emphasized the importance of these tests in evaluating the hearing following exposure to pressure. Anyone exposed to pressure either in employment or in recreation should have the hearing tested before and after indulging in such activity and every year thereafter.

Case 2. P. C., aged 26 years, a diver at the Marine Studios for seven years, complained in November, 1958, of fullness in the right ear since the ear became stopped up five months previously while he was diving. He experienced difficulty in clearing this ear, but continued to dive. Two weeks before I examined him, he had an upper respiratory infection and experienced great difficulty in clearing the ears while diving. On one dive to a depth of 12 feet for two minutes, severe pain in the right ear forced him to ascend and have a substitute diver take his place. He attempted to dive a week later and was unable to clear this ear. He had previously noted epistaxis, but had experienced only slight difficulty when diving with an upper respiratory infection. He admitted no exposure to excessive noises. Aware of the experience of the diver in *Case 1*, he was concerned about losing his hearing.

Except for a suggestive dullness of the right tympanic membrane, both tympanic membranes appeared to be normal The reaction to the Rinné test was positive bilaterally, and the Weber test lateralized to the left ear The nasopharynx was free of lymphoid tissue Both eustachian tubes were readily inflated, but the right ear felt more stopped up after the inflation The audiogram showed

	128	250	500	1000	2000	4000	8000
Right	10	5	-5	0	5	30	0
Left	15	15	10	5	5	30	0

My diagnosis was subacute tubotympanitis, and he was advised to refrain from diving for several weeks In January, 1959, he continued to complain of a tight feeling in the right ear A week previously, on attempting another dive, he had experienced severe pain in this ear as he stepped off the ladder to the bottom of the pool Since he could not equalize the pressure in the ear, he came to the surface and again experienced fullness in the right ear for several hours Examination gave the same results as previously

The use of radium in the nasopharynx was suggested to him, but declined when the inherent dangers and known effects of this treatment were explained to him He elected to give up diving as a profession and perhaps act as a substitute diver at some future time should the difficulty clear up

Comment It is noteworthy that this diver experienced trouble after seven years of diving He appeared to be emotionally stable and well satisfied with his work There were no known compensation incentives

A 24-year-old diver was observed immediately after ascending from a 40-minute dive to a depth of 12 to 18 feet at the Marine Studios He had used a compressed air helmet, receiving compressed air at 25 pounds per square inch His ears had blocked as he descended the ladder, but he was able to clear them by swallowing and noted no pain Examination gave normal results Examination of a diver, aged 23 years, resulted in normal findings under similar circumstances Both men had been diving for approximately a year, had noted no hearing loss and had no difficulty in clearing the ears Occasionally, however, they experienced pain in the ears and slight epistaxis when diving with a mild upper respiratory infection

Aerosinusitis

The etiology of aerosinusitis is similar to that of aero-otitis media The pressure differential between the sinus cavity and the ambient pressure is the deciding etiologic factor Again, the severity of the sinus barotrauma is related to the degree and duration of the pressure differential The larger sinuses are involved more frequently than the smaller ones The maxillary and frontal sinuses are most commonly affected because of the small orifices The length and tortuosity of the nasofrontal duct make the frontal sinus more susceptible to barotrauma Any obstruction to a sinus ostium is conducive to aerosinusitis On descent, the ostium is blocked and a differential in pressure ensues, resulting in a vacuum in the involved sinus The negative pressure in the sinus must be equalized by some physiological mechanism Engorgement of the blood vessels, edema of the mucosa, and hemorrhage in the sinuses result in equalizing the pressure in the sinus When the space is filled sufficiently to equalize the pressure differential, the ostium will open The symptoms may vary from a dull feeling in the affected sinus to severe pain There may be hemorrhage from the nose in severe aerosinusitis

Sound Transmission

Sound is transmitted well underwater, traveling 4,800 feet per second in water as compared to 1,090 feet in air It is, nevertheless, difficult to communicate with the voice underwater because of the difference in inertia and viscosity between air and water Only about one part in 10,000 of the sound energy enters the water when one speaks into an ordinary mask[19] For the scuba diver, speech is further complicated by the obstructing mouthpiece and the noise of escaping air during exhalation Localization of sound is also more difficult under water than in air, probably because the high velocity of sound in water reduces by a factor of five the small difference in the arrival time of sound at the two sides of the head The endolymph is largely mobilized through bone-conducted sounds[37]

Air Embolism

Air embolism is a potentially fatal accident of scuba diving Lanphier[33] believed it second only to drowning as a cause of death in this sport In skin diving without a self-contained breathing apparatus, the air in the lung of the diver is compressed on descent as is the wall of the chest On ascent, the pressure of the air in his lung returns to the ambient atmospheric pressure This diver is not subject to an air embolism

The scuba diver with his self-contained breathing apparatus takes into his lungs compressed air delivered at the ambient pressure of the water If he ascends slowly, breathing regularly, the lung will equalize the pressure to the ambient pressure of ascent If he holds his breath for one reason or another, such as ignorance, panic, or unconsciousness, the air in the lungs will expand with ascent, and if the ascent is from a great depth at a rapid rate, the alveoli are apt to rupture, and an air embolism is likely to develop The expanding air on ascent increases the intrapulmonary air pressures sufficiently to overdistend the lungs and rupture the alveoli The danger to the scuba diver is explained in Fig 4

There are two types of air embolism, pulmonary (venous) and systemic (arterial) A pulmonary air embolism results from a large amount of air entering the systemic circulation and going to the right side of the heart Foaming blood containing large bubbles of air forms, which is more compressible than normal blood and less readily expelled There is a retention of air following each systole The presence of air in the right ventricle produces a loud churning sound, which is readily heard without a stethoscope, and is known as a mill wheel murmur There is a resultant obstruction of the right ventricular outflow due to the air trap which forms in it The pulmonary circulation is obstructed, and the right auricle and ventricle become distended A pronounced rise in the venous pressure is followed by cyanosis and sudden death

The position of the patient with a pulmonary air embolism may be life-saving[16] Turning him on his left side permits the outflow of the right ventricle to be in the dependent position The trapped air then disappears from the inferior position and is churned into a froth and mixed with blood in the right ventricular cavity This may be a life-saving maneuver Pulmonary air embolism may follow wounds or operation in which the dural sinuses are injured The walls

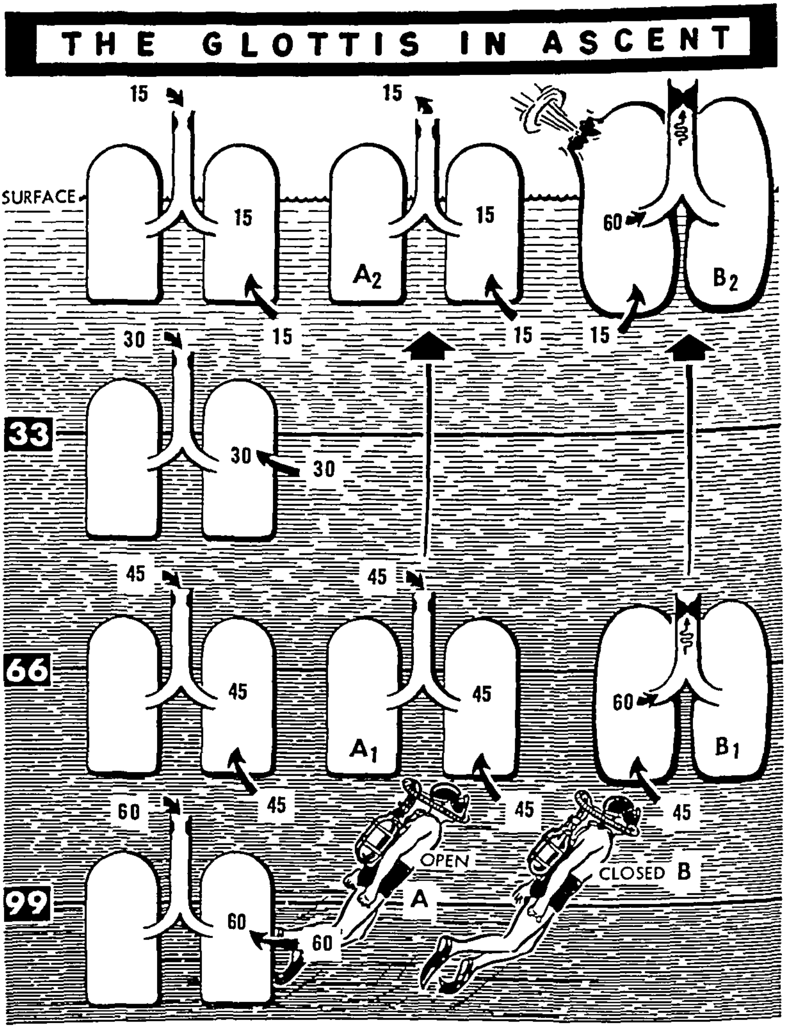

Fig 4 The Glottis in Ascent Divers descend with scuba to 99 feet (4 atmospheres of pressure) The lung remains the same The lung pressure varies directly with the ambient pressure

Diver A ascending slowly exhales with the glottis open At the surface the lung pressure is equal to the atmospheric pressure

Diver B panics because of defective equipment closes the glottis to preserve air in the lung and makes a rapid ascent With ascent the air in the lung expands At the surface the atmospheric pressure is 15 pounds and his lung pressure is 60 pounds Rupture of the lung ensues causing air embolism, pneumothorax or emphysema of these sinuses, being semirigid, favor the entrance of air Replacing the fluid with air following an antral irrigation may result in a pulmonary (venous) embolism Both situations occur in the field of otolaryngology

Systemic (arterial) embolism results from air getting into the pulmonary venous channels It is then propelled to the left ventricle and the systemic circulation Ill effect is due to an embolic blockage of the cerebral and coronary vessels This type occurs most frequently in scuba diving

Kinsey[26] reported four cases of air embolism to illustrate the various symptoms and treatments One man, after ascending 50 feet in the submarine escape training tank at the U S Naval Submarine Base in New London, was seen thrashing around on the surface, apparently in a convulsion Frothy red fluid issued from his mouth He was unconscious and in a convulsive state when taken to the recompression chamber nearby, shortly thereafter he died Autopsy revealed widely dispersed air bubbles in all of the cortical blood vessels Some vessels contained so much air that nearly all of the blood was forced out, leaving a 2 to 3 cm expanse of blood vessel free of blood Blebs filled with air were present over the pleura Pronounced dilatation of the right auricle and atrium, and moderate dilatation of the left atrium and auricle was present, and there was air in the left auricle and atrium In a similar case which came to autopsy after a fatal accident from air embolism, both the right and left auricles and ventricles were dilated by air All major vessels encountered showed evidence of air, and the largest amount of air was expressed from the aorta and the superior vena cava

Cases illustrating mediastinal and subcutaneous emphysema and mild cerebral vascular occlusion secondary to air embolism were cited by Kinsey[26] In mediastinal and subcutaneous emphysema the alveoli are torn, and the air follows the pulmonary vessels to the mediastinum and then into the neck through the fascial planes In cerebral embolism the air is carried to the left ventricle after entering small interstitial veins, producing arterial air emboli The air causing dilatation on the left side of the heart is probably introduced through the pulmonary veins In his case with air in both sides of the heart, Kinsey[25] suggested that the air passed through the pulmonary lymphatic vessels to the large veins of the neck and thence to the right side of the heart The large volume of air in the right auricle results in a cardiac tampon of blood (see Fig 5)

Role of the Larynx The larynx plays a particularly im-

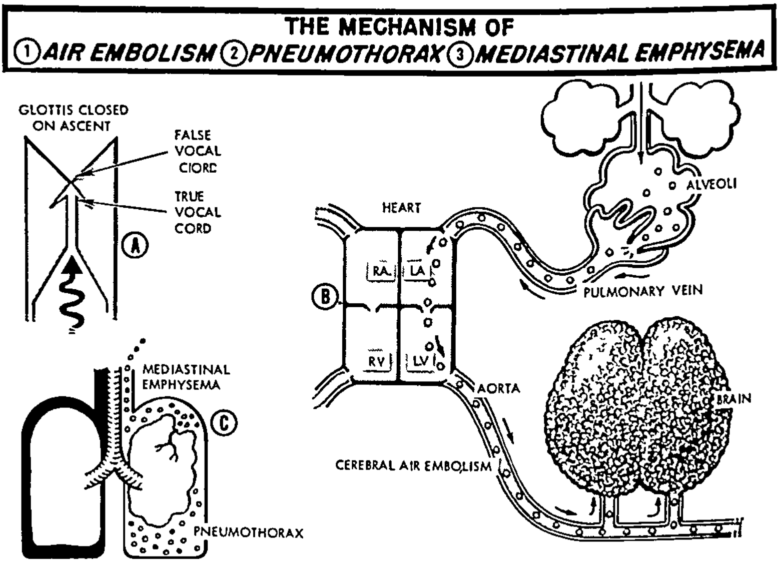

Fig 5 The mechanism of (1) air embolism (2) pneumothorax and (3) mediastinal emphysema

A The glottis closes The false cords prevent exhaling of air

B Increased lung pressure ruptures alveoli Air enters the pulmonary circulation passes to the left side of the heart and then to the cerebral or coronary circulation as an embolus

C A pleural bleb may form and rupture forming a pneumothorax Air may dissect along the pulmonary vessels or bronchi to the mediastinum to form a mediastinal and subcutaneous emphysema

portant role in the etiology of air embolism Phylogenetically, the larynx was most important in the evolution from water to land habitation The most primitive larynx was found in the dipnoea, or lung fish[46] It evolved because of the need for oxygen in these fish when existing in water with a limited or undependable supply of oxygen Although the development of lungs capable of absorbing oxygen was a boon to them, it created the necessity for a means of keeping the water out of the lung during submersion, otherwise, survival would not have been possible In the lung fish there developed a simple circular group of muscle fibers at the upper end of the trachea to serve as a sphincter to close off the trachea during submersion It is believed that this simple mechanism is the forerunner of the human larynx

Phylogenetically then, it appears that the most primitive function of the larynx is one of protecting the lower portion of the respiratory tract, which is carried out by adduction of the laryngeal sphincter It is ironic that the same mechanism which made possible the evolution of man from the sea may prove to be lethal to him during his return to the sea with his newly created breathing apparatus The ingress and egress of air from the lungs are controlled by the valvular action of the true vocal cords and the false vocal cords The true cords and false cords control the to-and-fro movement of air through the larynx Because of the unique design, the valvular action is more powerful than the muscular sphincter effect These functions are under both voluntary and involuntary control, supplied by the higher cortical centers and medulla in the brain The true vocal cord acts as a valve which controls the ingress of air, and the false vocal cord controls the egress of air The cortical centers allow one to hold his breath at will by adducting the cords until carbon dioxide is accumulated sufficiently to stimulate the respiratory centers of the medulla so strongly that the voluntary control is inhibited and the cords abduct as in forced expiration [46] Reflex cessation of inspiration and tight adduction of the true vocal cords result when food or water or other foreign substances incite the sensory innervation of the larynx False cords are tightly closed for the purpose of developing intrathoracic pressure by trapping air below the larynx This mechanism is used in coughing, vomiting, defecation, urination, and parturition

An emotional control is also exerted on the larynx Beginning with the birth cry, the larynx reflects the emotional states throughout life One's state of mind can frequently be diagnosed by listening to the voice Fears and tensions are reflected by a high-pitched intense voice The larynx reverts to its protective reflex when provoked by one's physical and/or emotional condition Stage fright and self consciousness are disastrous to the singer, and neurotic conditions are reflected in the neuromuscular reflexes of the larynx[22]

While practicing with my scuba equipment in a swimming pool and learning to clear my mask, which consists of blowing water out of the face mask by positive pressure, I inhaled some water far posteriorly in my nose This immediately set up a mass pharyngeal reflex and a mild laryngospasm, which persisted after I came to the surface I talked in a high-pitched voice and had a paroxysm of coughing for several minutes At a greater depth under less favorable circumstances than a swimming pool offered, such a sequence could be potentially fatal to as inexperienced a scuba diver as I was It is essential for the scuba diver to learn to breathe through the scuba mouthpiece without his face mask

Panic is the greatest hazard experienced by the skin and scuba diver Several divers, in describing a condition of panic or near panic, have all volunteered a sensation of tension in the throat Free ascent is a rapid ascent made when the scuba is defective, a diver exhausts his air supply, or his mouthpiece is dislodged His cortical centers, if active, will abduct the cords so that air can be exhaled on his way to the surface His emotional or reflex centers, stimulated by panic, may incite adduction of the cords because of his innate instinct to hold his breath on his way to the surface If a laryngospasm due to inhalation of a small amount of water is superimposed, he will be a likely candidate for an air embolism It is of the utmost importance that the diver be thoroughly familiar with the mechanism involved in the prevention of air embolism (see Fig 4)

Treatment of air embolism consists of recompression in the recompression chamber under medical supervision Recompression compresses the air bubbles to asymtomatic size, allowing the gas to return into solution and be removed by the blood According to Lanphier,[33] failure to recognize air embolism or decompression sickness in a patient who has been using diving equipment is the most serious mistake possible

The two may be indistinguishable, but both require recompression. Failure to recompress is apt to result in permanent injury or death. Physicians should know where the nearest recompression chamber is. Frequently it is many miles away. While the patient is en route to the chamber, he should be kept in a head low position to minimize the possibility of air entering the cerebral circulation. When air is in the right side of the heart, he should be placed in a left lateral position to displace the air trapped in the right ventricle.

Decompression Sickness

Commonly known as bends and as caisson disease, decompression sickness is less of a danger to the scuba diver than is air embolism. The limited supply of air prevents his descending deep enough for a sufficient length of time to permit this illness to develop. It is unlikely to occur unless the diver carries several tanks or makes several deep dives in a single day. Gas dissolves in the body when under pressure and evolves when the pressure is released. Decompression sickness is due to the rapid release of nitrogen from the tissues on too rapid ascent. The gas evolves faster than the blood stream can carry it away and release it in the lung. Bubbles may form in the blood stream which may block the flow of the blood in the capillaries. Vail[59] reported deafness resulting from bubbles of nitrogen forming emboli or areas of necrosis in the internal ear. Permanent deafness may result. Shilling and Everley[50] presented evidence to show that even though decompression sickness may cause deafness, it rarely does so.

ANALYSIS OF SERIES

The study of 38 divers here reported resulted from the interest stimulated by the earlier work of Taylor[51-53] pertaining to man's lack of adaptation to an aquatic environment. It has long been my desire to extend this research to the subaquatic environment. I first familiarized myself with the literature provided for the study of the skin and scuba diver. Then I received instructions in a swimming pool from two local physicians who were enthusiasts in both skin and scuba diving, also, I attended the meetings of a local club of experienced divers, known as the Jetty Jumpers.

In the course of studying a group of 38 skin and scuba divers, I submitted to them a questionnaire consisting of 39 questions and analyzed their replies In addition, I performed a complete otolaryngological examination on all 36 men and two women in the group The audiometric studies were carried out in a sound-proof hearing room (model 401, Industrial Acoustics) with a Beltone 15-A Audiometer The divers, ranging in age from 16 to 44, were all experienced, 11 had been skin diving for over ten years and 18 for over four years Observations were made on several of these divers at Troy Spring, a spring 100 feet in depth on the shores of the Suwannee river The first observation was made after a descent to 33 feet and the next to 66 feet The divers at the Marine Studios at Marineland on the east coast of Florida were examined before and after diving My personal experience with barotrauma is included in the study Observations made on the "mermaids" at Weeki Wachee Spring on the west coast of Florida are also reported, although these divers are not included in the series of 38 studied

The enthusiasm of the skin and scuba divers in the series seemed to exceed by far that of the participants in other sports This sport was more than an athletic contest to them They were constantly seeking new knowledge, they were eager to learn about the physics of diving, physiology, marine biology, paleontology, archaeology and ichthyology The Jetty Jumpers made it a practice to meet weekly throughout the year in their search for knowledge and to share experiences They were fully aware of the dangers involved in this sport and made every effort to learn and stress the various safety factors

It has been suggested that the relatively short, wide and straight eustachian tube of the child tends to make children more prone to ear infections If this were true, one might assume that the person having the greatest number of ear infections in childhood would tend to have less difficulty in establishing patency of the eustachian tube when exposed to pressure It is noteworthy that of the 38 divers, only six volunteered that they had any ear infections in childhood (see Table I) None of these experienced difficulty in autoinflation of the eustachian tube They seemed, however, on the average, to have as much difficulty equalizing pressure in their ears while diving as the remainder of the group

Barotrauma in Flying and Diving

On the assumption that the individual responses to barotrauma in commercial flying and in swimming pools might be of significance in their ability to withstand pressure, the divers were asked to give their responses to the changes experienced (see Table II) Of four who could not descend to the bottom of a 10 to 12 foot swimming pool without pain in the ears or sinuses, and four who had difficulty equalizing the pressure in their ears while flying, only one had difficulty in both flight and diving With a slight upper respiratory infection they had more difficulty than those not having this

TABLE I

Past History of Otolaryngologic Difficulties

	Yes	No
Frequent upper respiratory infections	11	27
Hay fever	8	30
Sinus trouble	12	26
Nasal obstruction, free of upper respiratory infection	8	30
Ear infections in childhood	6	32

TABLE II

Observations Associated with Diving

	Yes	No
Can descend to bottom of swimming pool without discomfort or pain in ears or sinuses	34	4
Difficulty equalizing pressure in ears while flying	4	34
Nasal bleeding during or following a dive	18	20
Perforated tympanic membrane during dive	3	35
Dizziness experienced during or following a dive	13	25
Tendency toward seasickness	10	28
Symptoms of decompression sickness following diving	1	37
History of panic	1	37
History of near panic	23	15
Encountered difficulty unable to handle without help while skin diving	7	31
Hearing loss following dive	9	29
Tinnitus following dive	16	22
Sinus involvement during or following a dive	20	18

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disability The diver volunteering difficulty in both situations had to clear his ears every five feet down Whenever he was unable to equalize the pressure adequately, he had intense pain in his ears Always after diving, the left ear felt stopped up for about an hour and the right ear for approximately one week His audiogram showed normal hearing

One of the subjects having difficulty with flying had more difficulty with his ears than any of the other divers while I observed him after attempting a descent of 65 feet He was unable to go deeper than 45 feet, and was one of the few I cautioned about the effect of skin diving on his ears One of the eight divers was unable to autoinflate the eustachian tube and the other seven in this category had a little more difficulty than usual They all had to clear their ears at less depth and more frequently than the divers not offering this complaint

Teed[55] showed that observing the tympanic membrane while the subject autoinflates his ears is of significance in determining how a person will respond to pressure I believe the person who has pain in his ears on descent in a pool and repeated difficulty in flying will show a poor response to pressure A recompression chamber is not available to most physicians or divers to test their responses to pressure I would tend to discourage the potential diver who gives such a history The only true test, however, of response under pressure in a subaquatic environment is by diving It is of extreme importance that divers be properly trained in autoinflating the eustachian tubes The diver with repeated bouts of barotrauma should be discouraged from diving and subjected to depths only at which he is free of pain in the ear

I believe that a person whose response to barotrauma both in flying and diving is similar to mine should be discouraged in this endeavor I had anticipated my response while flying I believe I shall be able to continue diving at shallow depths and also that at a much more gradual rate of descent, I might not have had the difficulty I encountered on the dive in which I attempted to reach a depth of 60 feet Case 3 is a record of my personal experience

Case 3 G D T an otolaryngologist, aged 40, had a history of an initial and a secondary tonsillectomy and adenoidectomy at ages six and 13 years, and prominence of lymphoid tissue on the pharynx posteriorly and in the nasopharynx as a child During his first two airplane flights in 1941 and 1943, covering 1,000 miles with eight stops and made soon after having a mild upper respiratory infection, he experienced severe aural and sinus pain, followed by a bilateral serous otitis media a loss of hearing of the conductive type and a bilateral low-pitched tinnitus of several days' duration After a similar flight in 1945, serous otitis media persisted for several days and was worse in the right ear than in the left. Radium was applied to each side of the nasopharynx. During the next 12 years various degrees of difficulty were associated with some ten or 12 flights varying in length from 150 to 1,500 miles

In May, 1958 after a flight of 3,000 miles with four stops at a maximum height of 20 000 feet he experienced severe sharp pain in the right ear and dull pain in the left ear on descent at the Los Angeles airport Appreciable loss of hearing persisted for one week in the left ear and for two months in the right ear and there was a low-pitched roaring tinnitus During sleep the right ear would clear but when he was operating the following morning with his head in the dependent position, the feeling of fullness would recur as the fluid entered the eustachian tube, and it would persist all day For removal of fluid from this ear paracentesis with inflation was resorted to during the fifth week and repeated ten days later

After three months had elapsed, this experience led to testing the response in a subaquatic environment Diving in a pool to a depth of eight or ten feet resulted in a feeling of stuffiness in the ears and a roaring tinnitus lasting several hours Early in November, at Troy Spring, on descending gradually to 40 feet with scuba equipment, he experienced little difficulty in inflating the left eustachian tube but much difficulty inflating the right tube On ascent, pain suffered at the 20 foot level led him to descend five feet before reascending At this point, the egress of air through the tube was distinctly audible Both tympanic membranes were inflamed and tinnitus persisted bilaterally for 48 hours

In mid-November on making a more rapid descent at Troy Spring than previously in an attempt to reach the 66 foot level he experienced pain at the ten foot level, could not open the right tube at the 40 foot level and at the 45 foot level suffered pain so severe that he made a gradual ascent On-the-spot tests were made with the AMBCO Otometer before and after diving and the hearing was above the 5 db level for each frequency both before and after the dive The left tympanic membrane was injected after the dive and the right one inflamed The next day the right ear felt as though it were full of fluid Two days later the left ear was open but the right ear felt tightly closed Bilaterally a roaring tinnitus persisted The left tympanic membrane appeared normal and the right tympanic membrane showed evidence of hemorrhage The ear was filled with fluid at that time and also two days later when the evidence of hemorrhage had subsided Ten days later the fluid had disappeared and the tympanic membrane had returned to normal Immediately following this dive, mild bleeding also occurred from each side of the nose and continued for several minutes after he came to the surface The first nosebleed he had ever experienced probably was caused mostly by pressure change in the sinuses and nose and the pressure of the face mask against the nose during frequent attempts to clear the ears

Early in December at Marine Studios he descended in a tank to a depth of 12 feet wearing a diver's helmet and a rubberized waterproof suit with 25 pounds of pressure fed through the compressed air hose

There was no appreciable change in the ears on descent or while down, but on ascent the eustachian tubes were blocked and remained so for two days The right ear felt blocked for a week, but there was no evidence of fluid in the ear

At Mayport, Fla , in mid-December, compression to a pressure equivalent of eight feet of water, in a recompression chamber, resulted in a completely blocked right tube at ten feet produced pain On flying, he had always noted that at an altitude above 7,000 feet he could tell when the plane started down, and he experienced gradual loss of hearing as the plane descended Despite yawning, swallowing and autoinflation, he was never able to open the eustachian tubes adequately He had also used antihistamines and nasal decongestants, but to no avail

The audiograms, made periodically, showed

May 30, 1958—

	128	250	500	1000	2000	4000	8000
Right	20	15	10	5	5	10	15
Left	5	0	5	5	–5	0	10

June 23, 1958—

	128	250	500	1000	2000	4000	8000
Right	20	10	5	5	15	20	35
Left							

October 6, 1958—

	128	250	500	1000	2000	4000	8000
Right	10	5	0	–10	0	10	10
Left	15	10	5	10	0	0	10

December 8, 1958—

	128	250	500	1000	2000	4000	8000
Right	20	15	5	0	0	30	35
Left	10	0	0	5	0	0	5

December 9, 1958—

	128	250	500	1000	2000	4000	8000
Right	20	15	0	0	0	20	20
Left	10	0	0	0	0	0	5

January 12 1959—

	128	250	500	1000	2000	4000	8000
Right	5	–10	–5	–5	–5	10	5
Left	5	–10	0	-5	–10	0	5

It is obvious from this record that his experiences with severe barotrauma during the preceding seven months resulted in no permanent damage to his hearing

Nasal Bleeding

Eighteen of the 38 divers examined in this study had experienced nasal bleeding during or following diving In the one severe instance, the diver had an upper respiratory infection, and the source of the bleeding was believed to be the frontal sinus This bleeding may result from the forced pressure of the face mask against the nose in an attempt to inflate the eustachian tube It may also result from a negative pressure in the nose created by improperly inflating the mask on descent by positive pressure from the nose to equalize the external pressure In none of those having frequent nosebleed was there noted a prominent vessel on the septum which might have caused the bleeding

Perforated Tympanic Membrane

Three divers presented a history of a known perforated tympanic membrane associated with diving In all, the lesion healed without treatment In making a rapid descent, if the diver is unable to equalize pressure in the middle ear with the ambient pressure, the eustachian tube will block completely. If he continues to dive after experiencing the sensation of pain, the tympanic membrane may suddenly rupture because of the increased external pressure Rupture is usually accompanied by pain which is not necessarily great There is the sensation of a change in tension, and a noise is heard in the head Severe dizziness may ensue from the introduction of water into the ear, setting up a caloric response in the semicircular canals

Case 4 J C a man 34 years of age with ten years' experience in skin diving, had had limited experience in scuba diving In 1946, while he was skin diving and spear fishing, he descended suddenly after noting a gar fish At a depth of eight to ten feet he experienced pain in the ears, but continued to descend without clearing them Sudden sharp pain in each ear ensued He then ascended and felt as though he were flopping around from side to side, more of a to and fro sensation than a true vertigo Both ears bled for a short time, and the pain persisted for two or three hours, but there was no appreciable loss of hearing At the Navy Dispensary he was told that both tympanic membranes were perforated He stayed out of the water for two or three weeks, and the perforations healed without treatment He believed he could have reached the surface without difficulty even from a much greater depth In 1948 the left tympanic membrane was perforated by shock from the firing of a large gun on shipboard He was able to blow smoke through the perforation, but experienced pain each time There was a loss of hearing for several days following this perforation, which healed without treatment

In December, 1949, while at the Submarine School in New London he made a free ascent from 100 feet and then dived down into the tank to a depth of ten to 15 feet, with perforation of the right tympanic membrane resulting The lesion, which was preceded and followed by pain, was confirmed by medical examination and healed without treatment In 1951, an attempt to dive to a depth of 17 feet resulted in perforation of both tympanic membranes He noticed that in each episode the pain was worse after the tympanic membrane ruptured While in the Bahamas diving for lobster in 1958, he experienced pain at a depth of 18 feet, but he went "the extra foot" without clearing his ears, and the tympanic membrane was again perforated He got the lobster after perforation of the tympanic membrane

In November, 1958, an audiogram showed

	128	250	500	1000	2000	4000	8000
Right	10	5	0	5	5	55	15
Left	5	5	5	10	0	50	20

Examination of the ears revealed atrophic areas involving most of the posterosuperior quadrant of each tympanic membrane With autoinflation there was a protrusion outward of these atrophic areas

Comment It is probable that the outward protrusions were the site of the perforations in this case The dip at the 4000 frequency in each ear was probably due to trauma associated with the exposure to gunfire during the patient's eight years of service in the United States Navy Behnke[5] noted a few proved cases of deafness arising from pressure trauma in contrast to the permanent aural damage caused by the exposure to the auditory trauma of gunfire

Case 5 C M, aged 30, experienced in skin diving for 20 years and in scuba diving for seven years, had three episodes of a perforated tympanic membrane secondary to diving The first bout occurred in the right ear at a depth of 40 feet, when he failed to clear the eustachian tube properly Pain and severe vertigo followed, the vertigo lasting for several minutes after he was out of the water A physician irrigated the ear with a solution which he believed contained mercury and also inserted grain alcohol drops into the ear He experienced severe vertigo during the irrigation and severe pain with the insertion of the alcohol The ear became badly infected and was washed out almost daily, the irrigation causing vertigo and pain each time The drainage continued for several weeks The physician informed him the perforation was still there and would always be present, and advised him against ever getting the ear wet Another physician, a year later, could see no evidence of perforation He started swimming again with no ill effects

Perforation of the left tympanic membrane occurred again the next year when he was at a depth of 25 feet because he failed to clear the ears properly He experienced immediate pain and vertigo Under treatment with sulfonamides and penicillin the ear healed in about two weeks Several months later, perforation of the right tympanic membrane with associated vertigo and pain occurred again while he was diving The vertigo lasted for about one minute after he got out of the water He was treated with antibiotics by another physician, who cauterized the ear after five days and again ten days later Healing was accomplished in three or four weeks

He then remained out of the water and refrained from flying for about two months He stated that a hearing test showed excellent hearing in both ears at both ends of the frequency range several months after the last perforation His physician told him that his hearing was much better than that of most of the people he tested In my study of this diver no audiometric test was made Examination of his left ear, however, revealed a healed posteroinferior perforation with an area of atrophic membrane at the site of the perforation The right tympanic membrane showed a large posteroinferior healed perforation with an area of atrophic membrane at the site

In every instance of perforated tympanic membrane in this series there was a history of vertigo following the rupture (see Fig 6) Haines and Harris[21] observed that a rupture of the tympanic membrane produces a loss of hearing not greater than 5 or 10 db

Case 6 J T, a man aged 32 years, one of the most experienced divers questioned, was experimenting in 1950 with ear plugs in each ear while scuba diving At a depth of 20 feet he experienced severe pain in the left ear, followed by a loud roaring sound When he surfaced, the left ear bled for several minutes Upon removal of the ear plug, he suffered severe pain when aerating the ear He consulted an otologist at once, who told him the posteroinferior portion of the tympanic membrane was perforated There was little change in the hearing after the perforation The rupture probably resulted from a differential pressure developing in the air space between the tympanic membrane and the ear plug The increasing pressure in the middle ear due to air from the scuba equipment under pressure probably perforated the tympanic membrane from within

Examination of his ears in November, 1958, revealed no abnormalities There was no evidence of scarring or atrophic areas on the tympanic membranes

An audiogram showed

	128	250	500	1000	2000	4000	8000
Right	5	0	–10	0	0	60	45
Left	5	5	–5	0	0	55	60

The high frequency loss shown in this audiogram was probably due to exposure to acoustic trauma sustained while he was in the armed services

One should never wear ear plugs while skin or scuba diving With a tight-fitting ear plug in the external auditory canal, a vacuum will develop between the plug and the tympanic membrane resulting in a differential of pressure If the pressure of the scuba delivering air into the mouthpiece is equal to the ambient pressure of the water which is pressing on

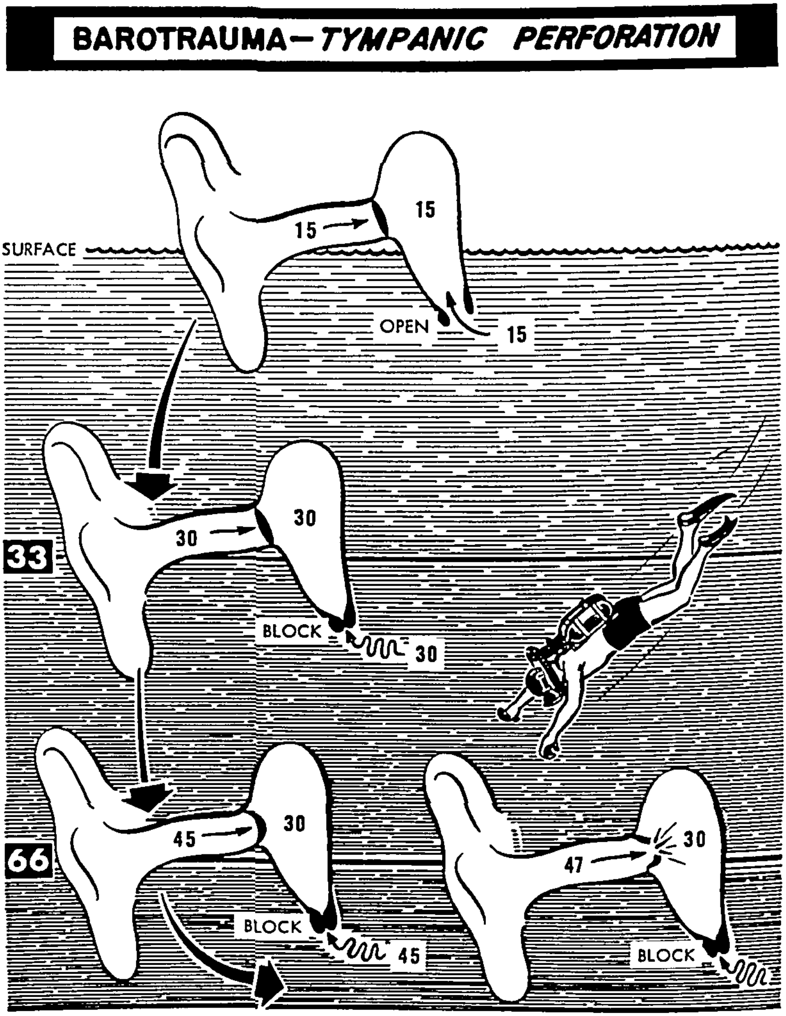

Fig 6 Barotrauma—Tympanic Perforation

A At the surface the eustachian tube is open and the pressures are equalized

B At 33 feet the pressure is equalized Blocking of the eustachian tube begins Pain ensues

C At 66 feet the diver ignores the pain and continues the descent The pressure is not equalized The tympanic membrane is pressed inward

D The tympanic membrane ruptures inward because of the difference of middle ear and ambient pressure the external surface of the plug, the tympanic membrane may rupture outward as the pressure in the middle ear increases If there is a blockage of the eustachian tube and the pressure is less than the ambient pressure, the plug may be pushed inward through the tympanic membrane in skin diving and in scuba diving (see Fig 7)

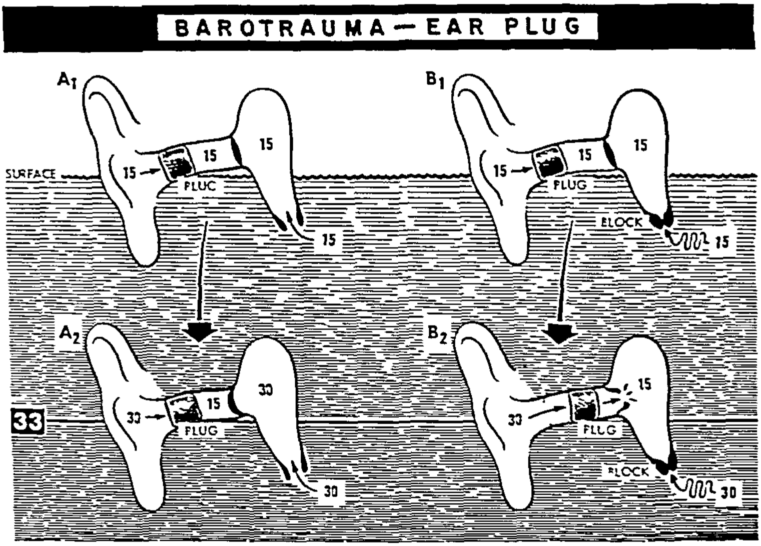

Fig 7 Barotrauma—Ear Plugs

A-1 Ear plug in the external auditory canal pressure equalized Wide open eustachian tube

A-2 Pressure differential in the canal between the ear plug and the tympanic membrane As the middle ear pressure increases the tympanic membrane bulges outward This bulging will lead to perforation if the pressure differential increases

B-1 Ear plug is in the canal the pressure is equalized The eustachian tube is narrow

B-2 The eustachian tube is blocked The ambient pressure forces the ear plug deep into the canal and the pressure ruptures the tympanic membrane

Dizziness, Seasickness, Bends, and Panic

Thirteen of the 38 divers had noticed a variable degree of dizziness associated with diving One stated that if he ascends faster than at the rate of 25 feet per minute, he becomes dizzy Ten were prone to seasickness The three who experienced motion sickness along the bottom of the sea attributed it to positional change due to the movement of the water while their eyes were fixed on the bottom as they searched for objects One highly experienced diver who had dived to a depth of 200 feet acknowledged symptoms of decompression sickness A most experienced and seemingly stable diver admitted having experienced panic on three occasions, once when left by his companion 400 feet back in an underwater cave, again when he lost his sense of direction in a spring, and a third time when he lost his visibility in a spring on another occasion Twenty-three of the 38 admitted situations in which they approached panic while 15 stated they had never been near panic in any situation The incidence of panic is probably greater than this study indicates, as divers are doubtless reticent about acknowledging it Seven divers had encountered difficulties while diving that they were unable to handle without help Of these, five admitted near panic

Loss of Hearing Associated with Diving

The nine divers in the series who noted loss of hearing during and following diving, attributed it to inability to equalize pressure through the eustachian tube The loss lasted from several hours to several days and varied in degree proportionately with the rapidity, duration and depth of descent None believed that they had sustained any permanent loss as a result of diving

Audiometric studies were carried out on the 38 subjects In two, a diagnosis of otosclerosis was made, they were the only ones in the series who were conscious of any permanent loss of hearing A composite audiogram showed high frequency losses, but most of these were, in my opinion, due to various exposures to acoustic trauma Dr Kenneth Wilson,[60] Director and Audiologist of the Speech Correction Clinic of Jacksonville, evaluated the 38 audiograms and made the following subjective observations

1 The group generally has hearing acuity within the limits of normal variation

2 A differential effect on hearing acuity in specific cases

is noted These cases can be attributed to pathological (or basic physiological) conditions, such as noise trauma, etc

3 Possible implications Some of these skin divers represent cases of hearing impairment not directly related to diving The physician should be alert to the need for advice concerning the possible effects of continued skin diving on the hearing impairment

Nine divers descended to a depth of 33 feet (two atmospheres) at Troy Spring for a duration of 20 minutes Hearing tests, made with the AMBCO Otometer before and after the dives, indicated no appreciable change in hearing in any diver In each diver the tympanic membrane was injected, also, the vessels in the region of the malleus and the posterosuperior portion of the tympanic membrane were injected, especially the vessels near the annulus In two of the divers there was a fullness posterosuperiorly The tympanic membrane was protruding in this area due to the increased pressure following inflation of the eustachian tube during the dive

Three weeks after the descent to 33 feet, ten divers were observed before and after descending to a depth of 66 feet for 15 minutes The blood vessels on the tympanic membrane were injected in the same area as after the 33 foot dive Except in one instance there was no definite change in hearing In one diver there was a loss of 15 db at the 4000 cycle in each ear, and at the 6000 cycle there was a 30 db loss in the left ear and a 10 db loss in the right ear The tympanic membranes were markedly inflamed, and there was fullness posterosuperiorly He was able to descend only to 40 feet because of severe pain and great difficulty in clearing his ears Ten days later his hearing had returned to his normal level Injection of the malleolar vessels on each tympanic membrane was still present

Tinnitus

Sixteen of the divers had noted a ringing sensation in their ears Of these, six did not relate the tinnitus to diving, and four had been subjected to sufficient acoustic trauma to give them the persistent tinnitus One proficient diver, aged 30, had had a persistent roaring tinnitus since 1957

Sinus Involvement

Twenty of the divers had sinus pain either when diving with a cold or when descending too rapidly, but it did not seem to be of too great significance to any of them. One had severe bleeding for a few minutes following a dive

Appearance of Tympanic Membrane

Prominent dilated blood vessels were observed along the malleus in seven divers In three, there were also vessels posterosuperiorly at the annulus These divers were examined in the office and none had been diving for at least a week This finding probably represents a chronic state of congestion in these vessels, which might result from the pressure differential developing with diving or the frequency of autoinflation The congestion seemed to be more pronounced in the ear which was the more difficult to clear I do not recall observing this condition in any other type of patient These vessels are the ones which are seen to be injected following diving

TABLE III

Greatest Diving Hazards in Opinion of Divers	
Panic	23
Ignorance	4
Foolhardiness	3
Other careless divers	3
Poor training	2
Air embolism	2
Bends	1

The posterosuperior portion of the tympanic membrane seemed most involved After a scuba dive, a ballooning out of this area, due to the increased pressure in the middle ear, was seen in some divers This area appears to bear most of the brunt in tubal inflation A flaccid atrophic area was present posterosuperiorly in four divers This area, well demonstrated on inflation, is the area which is seen protruding outward after inflation, following diving Campbell,[56] in discussing Teed's paper, stated that frequent autoinflation or politzerization does not lead to flaccid tympanic membranes

Miscellaneous

Eighteen divers had more difficulty clearing their ears when free diving, and nine when scuba diving, 11 noticed no difference There were 20 smokers and 18 nonsmokers in the group In regard to the relationship of diving to respiratory infections, one noticed an increase, eight a decrease and 29 no change

Divers' Observations

In the opinion of the divers, the greatest hazards to life resulting from diving are man-made; namely, panic, ignorance, foolhardiness, other careless divers, poor training, air embolism and bends (see Table III). Thirteen had learned skin and scuba diving by self instruction through reading books and then diving, 21 by diving with experienced divers and only four by organized supervision To prevent fatalities secondary to this sport, it would seem most important that organized supervision be encouraged

One diver admitted that in most every dive "something will surprise you and scare you half to death" One of his worst scares was when a six-inch fish swam into his mask while he was working around some piling Despite the frightening experiences, he acknowledged no inclination to panic and related that he tested himself to see how he would respond to panic situations He had gone down in 30 feet of water and then gone into the mud to a depth of 10 feet as a proof of stability Believing that cave diving gives one confidence, he had gone far back into a cave tunnel, shut off his source of light, taken off his mask and removed his mouthpiece He had further tested himself by ascending from great depths with his mouthpiece out

Several divers commented that the more they dived the easier it was to clear their ears, if they skipped two or three weeks, they had greater difficulty, and at the beginning of the season they always experienced the greatest difficulty One diver observed that when he was skin diving at five feet or deeper and swimming parallel to the bottom of the ocean with one ear higher than the other, he would always experience greater pain in the dependent ear Many of the divers volunteered the comment that it is most important to clear the ears gradually and thoroughly during the first ten to 20 feet of descent. One thought that once he had passed 33 feet (two atmospheres absolute) and had cleared his ears properly, it mattered little how deep he went as far as the pressure in the ears was concerned. Gradual descent is important so that the air may flow through the eustachian tube to equalize the pressure in the middle ear. According to Boyle's law, the volume of gas which must pass through the tube is less for the same depth change at greater depths below the surface. The diver, therefore, does not have to stop his descent so frequently to equalize pressures below the depth of the first pause at ten or 15 feet. When the pressure is equalized in a well ventilated tube, he probably will not have to stop again for 40 to 60 feet, and then not again unless making a dive beyond 120 feet if the pressures were completely equalized at each pause.[37] One diver mentioned that dark or black water made his throat "tighten up," and another said that when he was frightened or emotionally upset, his throat felt closed. A woman diver was of the opinion that women are just as good at skin and scuba diving as men.

OBSERVATIONS AT WEEKI WACHEE SPRING

Displaying courage, grace and beauty in a magnificent underwater show, the "mermaids" at Weeki Wachee Spring demonstrate admirably how well one may adapt to an aquatic environment with proper precautions and training. Their underwater acts are so well carried out that it is difficult to believe they are submerged. Trained by Mrs. Charles R. McNabb, herself an excellent performer, they know diving physics as well as diving physiology, and are fully aware of the effects of pressure on the human body. They are not allowed to dive with any sign of an infection of the upper respiratory tract and must surface at once and be replaced if they are unable to clear their ears or sinuses during a performance. Usually, they present one or two shows a day, but sometimes as many as four. Their average age is 19 years, and they come from all parts of the country.[30]

The show consists of various acts taking place underwater continuously for 30 minutes The performers present an excellent display of control of buoyancy by the amount of air inhaled and exhaled, as they breathe out, they descend, and as they inhale, they ascend, with no movement of the hands or legs They breathe through a hose which delivers air pressure at 88 to 120 pounds per square inch By proper control of breathing and swallowing, they eat a banana underwater with ease and then drink a bottle of soda pop The graceful ballet they perform illustrates excellent breathing control One diver makes a deep dive and then prolongs ascent without the air hose by engaging in ballet antics as she constantly exhales on the way to the surface

The performers have less respiratory infection than employees not diving The greatest difficulty is with the ears and sinuses Alcohol drops are introduced into the ears after every dive It is estimated that these girls are unable to dive 10 per cent of the time because of upper respiratory infections or other illnesses[39]

At the time my studies were made, the air temperature varied from 61° to 70° F, and the water temperature was 74 2° F The most striking observation was the great loss of body heat experienced by each diver The temperature changes in four subjects before and after they had been completely submerged in water for 30 minutes were

	Before	After
F M C	99 2	93 2
Q A S	99 6	95 0
N N	98 0	94 8
M W	99 0	93 4

There was an average loss of 4 85 degrees The temperature was taken just before descent and immediately on coming out of the water That these girls were all very cold was manifested by shivering, chattering teeth, goose pimples, and a reddish-purplish hue to their skin After being exposed to such temperature change one to four times daily five or six days a week, it is surprising that they have a low incidence of infection. They take a hot shower shortly after coming out of the water and then dress in warm quarters.

Noting that the human organism must maintain a constant average temperature of 98.6° F., Taylor and Dyrenforth[54] concluded that any considerable degree of deviation from this average for appreciable periods of time will result in morbid changes in the body. They further demonstrated that cold water has a veritable appetite for heat. Since the ratio of conductivity of water to air is 27 to 1, it follows that water takes heat from the body 27 times faster than does air. Almost all heat transfer under water is dependent upon conduction of heat from the skin to the water. The body loses more heat than it produces. The degree of heat loss under water is determined by the temperature of the surrounding water, the resistance of the body surfaces, and the resistance of the material worn. Calories must be consumed to help in maintaining a constant temperature.[37] The colder the water the greater the caloric consumption. This increases the metabolic rate, increases the need for air consumption in scuba diving, and leads to fatigue and exhaustion.

Man lacks a compensating mechanism for the maintenance of an average normal temperature such as is seen in aquatic birds and animals. These girls wear regular bathing suits. Their only protection is not to stay underwater too long and to restore their normal body temperature as soon after they dive as possible. Man's ingenuity has been an aid in allowing him to compensate somewhat for his temperature changes in water. Two types of suits have been designed, the wet suit and the dry suit. The wet suit is constructed of rubber or foam neoprene material and allows a small amount of water to enter the suit, which is not able to circulate. The body heat warms this small amount of water, and it acts as an insulating barrier against the cold water. Air affords better insulation than water. The dry suit is an air-tight, tight-fitting rubber suit under which woolen underwear can be worn. The air in the suit is warmed and helps maintain the body heat. Should these girls abandon their present mode of attire with its aesthetic appeal and wear these suits, they would be better able to maintain their normal body temperature, but would find it more difficult to attract the present audiences

The ears of seven girls were examined before and after diving Several of them made two or three dives during the day Hearing tests were made under poor testing conditions, with a Beltone 10-A Audiometer. There was no appreciable change noted before and after diving In all but one, the tympanic membrane showed no significant change There was a mild injection of the blood vessels posterosuperiorly and along the malleus, as was observed in the series of 38 divers studied In the girls going to the greatest depths more injection of the vessels was present than in those participating in the more shallow dives

Case 7 N N, a 23-year old diver who has been skin diving for six months, stated she had frequent colds and believed "sinus trouble" had developed since she began to dive Four months previously she experienced pain in the right ear, followed by a feeling of fullness and a loss of hearing, evidently an aero otitis media with formation of fluid in the middle ear The condition necessitated a paracentesis by a physician on four different occasions during a period of one month Since then, on diving, she had had a great deal of difficulty in clearing the right ear, especially during the first ten to 20 feet of descent, and had experienced an occasional pain in this ear, especially if she had any sign of an upper respiratory infection It is noteworthy that she had less difficulty clearing her ears with her head up than when in the dependent position

She complained of frequent pressure over the eyes and pain in the head and nose Otoscopic examination of the right ear before diving revealed an injection of the malleolar vessels A prominent vessel was present on the anterior edge of the malleus and one on the posterior edge A dilated vessel was prominent posterosuperiorly at the annulus There was slight injection of the malleolar vessels in the left tympanic membrane After the first dive there was no change in the left ear In the right tympanic membrane there was moderate retraction, and the vessels were markedly injected over the malleus posterosuperiorly I observed this ear at one hour intervals for the next six hours She made one other dive during this period The right ear was improved after the second dive Several hours later the ears had the same appearance as they had before the dives

Comment This diver represents the type of person I think should give up diving I believe that if she continues to have trouble equalizing pressure in her right ear, she will be apt to suffer a hearing loss At the present time she has no hearing impairment Comparison of the findings on her ear after the first and second dives appeared to indicate a tube in which the pressure had not been equalized of infection They take a hot shower shortly after coming out of the water and then dress in warm quarters

Noting that the human organism must maintain a constant average temperature of 98 6° F, Taylor and Dyrenforth[54] concluded that any considerable degree of deviation from this average for appreciable periods of time will result in morbid changes in the body They further demonstrated that cold water has a veritable appetite for heat Since the ratio of conductivity of water to air is 27 to 1, it follows that water takes heat from the body 27 times faster than does air Almost all heat transfer under water is dependent upon conduction of heat from the skin to the water The body loses more heat than it produces The degree of heat loss under water is determined by the temperature of the surrounding water, the resistance of the body surfaces, and the resistance of the material worn Calories must be consumed to help in maintaining a constant temperature[37] The colder the water the greater the caloric consumption This increases the metabolic rate, increases the need for air consumption in scuba diving, and leads to fatigue and exhaustion

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DISCUSSION

Carefully supervised instruction in skin and scuba diving by experienced divers is most important in the prevention of accidents and death from this sport Rigid tests should be passed by the student before he should consider himself capable of this potentially dangerous activity The potential dangers of scuba diving have been taken entirely too lightly Television, motion pictures and magazines have brought the fascination of this sport to millions of enthusiasts, but too little of the potential dangers have been made known to them Local skin diving clubs should set up carefully controlled and rigid courses for skin divers, and certification should be the aim of these local and national skin diving associations and such organizations as the American Red Cross The Conference for National Co-operation in Aquatics has made available a book[48] entitled "The Science of Skin and Scuba Diving," which serves as an excellent training manual and source of information for all divers The increasing popularity of this sport indicates that some form of certification must be set up if potential deaths are to be prevented

The U S Divers Company,[47] makers of the Aqua-Lung, find the heaviest participation in scuba diving in California, Florida, New England, the Greater New York and Upper New York State area, Michigan, Oregon and Washington, in the order named This company would not attempt to give an accurate figure on the number of skin and scuba divers in the United States at the present time, but estimated there are several million Its sales volume has doubled in the past year

The United States Public Health Service has no statistics on the number of deaths occurring annually in this country due to skin and scuba diving It would be of interest and important to have this annual death rate In 1956, 6,139 persons drowned in the United States Lanphier[31] stated that there is no civilian information on any reliable scale pertaining to the mortality figures of the skin divers It is his impression that the actual rate is much lower than the extent and average quality of sports diving activity would lead him as

Dr Maurice Haddad, who has observed the girls at Weeki Wachee Spring for six years, reported external otitis as the most common complaint During the Summer, when it occurs most frequently, he sees about one girl a week, but the use of ear drops, before and after swimming, has reduced the incidence of this disease He encounters aero-otitis media only occasionally, and rarely in acute form, he estimated that he performs myringotomy six or eight times a year in treatment Frontal sinusitis with a vacuum type of headache is not uncommon Three or four of the girls have a high septal deflection He performed a submucous resection on two of them this year, which gave relief In his opinion, they have an inflammation of the eustachian tube, following which they experience vertigo underwater Two of them lost their sense of direction, and one tended to have a fainting spell He attributed these reactions to a pressure phenomenon in the middle ear, but did not believe there was subsequent loss of hearing Most of the girls stay on the staff for only one or two years He concluded that they have no more difficulty than the general population except for respiratory infections He performed an adenoidectomy during the past year on two of them

CONTRAINDICATIONS

Difficulty in equalizing pressure in the ears and sinuses is the main contraindication to skin diving and scuba diving from the otolaryngological standpoint Inability to inflate the eustachian tube properly is probably the greatest limiting factor to this form of diving A person who has this difficulty on going to the bottom of a pool or while flying will probably have difficulty with diving A perforated tympanic membrane is a definite contraindication The danger of vertiginous attacks secondary to water getting into the middle ear could be a serious consequence A person with dizziness secondary to endolymphatic hydrops or other etiological factors should not dive, and one with chronic recurrent external otitis would have a difficult time Unless a person is in good general health and capable of standing up under emotional strain and physical duress, he should not indulge in this sport his face and blow the water out of it This maneuver could be life-saving on occasion

One need only to read of the exploits of the Navy underwater demolition teams to realize how well man has been able to adapt himself to an aquatic and subaquatic environment Yarbro[61] believed that the main problem of these underwater swimmers today is countermeasures initiated and imposed by the enemy In describing the tremendous handicaps and physical strain they must endure, he concluded that this military vocation requires a stout physique, a stout intellect, and a stout heart

One of Florida's most experienced skin divers, Charles R McNabb,[38] recently related his experience in removing the bodies of two 17-year-old divers from Salt Spring in western Florida, near Weeki Wachee Spring Three divers entered a narrow undeground stream 125 feet deep, wearing standard tanks with enough air for only a very short time at this depth, and carrying no guide line to lead them back to the surface Describing the tragedy in which two of them met death, he said "I can only hope that God grant every diver a mental picture of the two bodies as I saw them lifeless in their watery tomb Know your equipment and know your own limitations Life is too precious to waste . There are far too many people today that, having purchased diving equipment and learning to breathe from it, decide they are divers Those of us that have been diving all these years, both for sport and as a profession, know the hazards and have been properly trained in the use of the equipment Until one has mastered the emergency techniques, such as clearing your mask, clearing hose breathing from another diver's mouthpiece, ditching equipment and making a free ascent, etc *you are not a diver* but a potential accident But most important of all after you have learned to use the equipment properly, *use good judgment*"

SUMMARY AND CONCLUSIONS

If man will understand and accept the limitations nature has placed on him in an aquatic environment, he may learn to adapt himself well to skin and scuba diving He need be a submarine medical officer to expect The death rate in Navy diving is probably less than one per year As participation in the sport of skin and scuba diving continues to grow, the death rate will be kept down only if there is adequate training for prospective divers

The difference between the upper part of the respiratory tract of man and that of the aquatic mammal lies not in the respiratory membrane, but in the aquatic mammal's ability to close the nares voluntarily or involuntarily Taylor[53] demonstrated that the aquatic mammal's most persistent modification for life in the water is the ability to close the external nares and protect the respiratory epithelium from the destructive action of water Man's rudimentary muscles for this purpose are now of value only in facial expression He then showed that man's one natural means of protecting the nasal mucous membrane while swimming is by the proper method of breathing By exhaling through the nose while the head is submerged and inhaling through the nose while the head is above water, the swimmer tends to maintain a proper air pressure in the nasal cavities, thereby protecting the sinuses and eustachian tube from water

Such a mechanism is more important in a subaquatic environment The face mask allows man to protect the nasal mucous membrane from the deleterious effects of water by inhaling and exhaling through the mouth without inhaling through the nose, which is sealed air-tight from the water by the pressure of the mask The mask also allows for excellent vision under water, which is not possible with the cornea exposed to the water The skin and scuba diver should know the proper method of using the mask and should be familiar with clearing the mask under water He must be prepared for the eventuality of his mask being accidentally displaced or broken Under such circumstances he must be able to breathe through his mouth with his nose not covered or occluded He does so by elevating the palate and occluding the posterior nares He also keeps a positive pressure in the nasal cavities by inhaling from time to time through his nose He should be able to pick up the mask underwater, put it on

The otolaryngologic aspects of skin and scuba diving, notably aero-otitis media, aerosinusitis, air embolism and decompression sickness, are discussed A study of a group of 38 divers is analyzed, and observations on divers at Weeki Wachee Spring are presented

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limited only by the physiology and physics which govern his being, and the amount of air his equipment makes available

Man has few structural adaptations for an aquatic or subaquatic environment Proper methods of breathing and intelligent use of the face mask, fins, snorkel and scuba allow him to adapt to the aquatic world

Loss of hearing resulting from aero-otitis associated with increased pressure is not common When present, it is the result of damage to the middle ear caused by the inability to equalize air pressures The person having difficulty equalizing pressure through the eustachian tube should not indulge in these sports

Skin diving and scuba diving are potentially fatal sports All participants should be thoroughly familiar with the physics and physiology of diving.

Air embolism may be a serious complication of scuba diving A scuba diver should be well versed in the mechanism and avoidance of air embolism

There may be a temporary loss of hearing when a person is subjected to pressure, but it usually subsides completely when the tissues of the middle ear have returned to normal.

Man's ability to adapt himself to a subaquatic environment by means of proper equipment, proper training and proper physical status is demonstrated by the feats of underwater demolition teams, of divers such as those at Weeki Wachee Spring, and expert skin and scuba divers throughout the world Without such expert experience, instructions and equipment, man may well destroy himself

Pain in the region of the ear and sinuses is probably man's greatest deterrent to the avocation of skin and scuba diving The greatest dangers to man's subaquatic adventures are ignorance and foolhardiness The person who is fearful of underwater and confined spaces should not and probably will not take up this avocation Those persons who are poorly trained in the proper methods of skin and scuba diving and the limitations nature has placed upon them are apt to experience panic underwater and thus court disaster

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STAPES MOBILIZATION, A PROBLEM IN COCHLEAR HYDRODYNAMICS*

Preliminary Report

JUERGEN TONNDORF, M.D.,†

Iowa City, Iowa

Histological evidence concerning cochlear lesions after experimental stapedial fractures in cats, recently has been presented by Singleton.[7] According to a personal communication with H. Schuknecht,[6] from whose laboratory the above paper had issued, this finding was not a singular one. Whereas, in the first few animals the lesions were observed in the upper basal turn, corresponding to a frequency of approximately 3,000 cps, more recently damage has been found to extend well into the second turn, *i. e.*, to approximately 1,500 cps. The lesions resemble somewhat those seen after a moderate acoustic trauma: haircells missing, not over large stretches, rather occasional gaps alternating with small islands of apparently intact cells. For anatomical details reference must be made to the paper by Singleton.[7]

After first being informed of these findings, this author was immediately reminded of observations made accidentally, but not infrequently, in his studies on cochlear models,[8] when either of the two cochlear windows was displaced inadvertently, a rather pronounced displacement of the cochlear partition ensued in its middle to lower portion; therefore, it seemed plausible to assume that the lesions observed by Singleton had been caused by stapedial displacements incurred during the manipulations at the stapes.

In order to obtain some preliminary information on this

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Marshall Taylor Doctors Bldg

COURS DE TECHNIQUE AUDIOMETRIQUE

The Faculty of Medicine, Paris France, will hold a Course in Audiometry, October 12-18, 1959, under the chairmanship of Prof M Aubry of the Clinic of Oto-Rhino-Laryngology The tentative program includes lectures on the scientific fundamentals, the technique of audiometry, discussions of the results and problems of interpretation, and round table discussions Professor Aubry will be assisted by MM les Professeurs Agreges J J Debain and R Maduro, les Docteurs P Aboulker, J Bouche, P Clerc, H Henriot, R Maspetion, J Pialoux, J Bouchet, M Burgeat, L Chevance, P-L Klotz, P Robert, B Vallancien, Mme S Borel-Maisonny, M le Professeur A Didier, MM R Chocholle, J-E Fournier, R Lehmann and A Molles The complete program will be ready in June, 1959 For further details write Secretariat Service Oto-Rhino-Laryngologique Pavillon Isambert, Hospital Larriboisiere 2 Rue Ambroise-Pare, Paris 10°), France

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Histological evidence concerning cochlear lesions after experimental stapedial fractures in cats, recently has been presented by Singleton.[7] According to a personal communication with H. Schuknecht,[6] from whose laboratory the above paper had issued, this finding was not a singular one. Whereas, in the first few animals the lesions were observed in the upper basal turn, corresponding to a frequency of approximately 3,000 cps, more recently damage has been found to extend well into the second turn, *i.e.*, to approximately 1,500 cps. The lesions resemble somewhat those seen after a moderate acoustic trauma: haircells missing, not overlarge stretches; rather occasional gaps alternating with small islands of apparently intact cells. For anatomical details reference must be made to the paper by Singleton.[7]

After first being informed of these findings, this author was immediately reminded of observations made accidentally, but not infrequently, in his studies on cochlear models[8] when either of the two cochlear windows was displaced inadvertently, a rather pronounced displacement of the cochlear partition ensued in its middle to lower portion; therefore, it seemed plausible to assume that the lesions observed by Singleton had been caused by stapedial displacements incurred during the manipulations at the stapes.

In order to obtain some preliminary information on this

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Marshall Taylor Doctors Bldg

COURS DE TECHNIQUE AUDIOMETRIQUE

The Faculty of Medicine, Paris France, will hold a Course in Audiometry, October 12-18, 1959, under the chairmanship of Prof M Aubry of the Clinic of Oto-Rhino-Laryngology The tentative program includes lectures on the scientific fundamentals, the technique of audiometry, discussions of the results and problems of interpretation, and round table discussions Professor Aubry will be assisted by MM les Professeurs Agreges J J Debain and R Maduro, les Docteurs P Aboulker, J Bouche, P Clerc, H Henrot, R Maspetion, J Pialoux, J Bouchet, M Burgeat, L Chevance, P -L Klotz, P Robert, B Vallancien, Mme S Borel-Maisonny, M le Professeur A Didier, MM R Chocholle, J -E Fournier, R Lehmann and A Molles The complete program will be ready in June, 1959 For further details write Secretariat Service Oto-Rhino-Laryngologique Pavillon Isambert, Hospital Lariboisiere 2 Rue Ambroise-Pare, Paris 10°), France a well defined length In that case the spectrum is also affected There is a trading relation between bandwidth and time duration, so that longer time durations are associated with lesser bandwidths and vice versa, therefore, the spectra of the two impulses of Figure 2, with their gradual onset, have a limited bandwidth, all energy being confined to lower

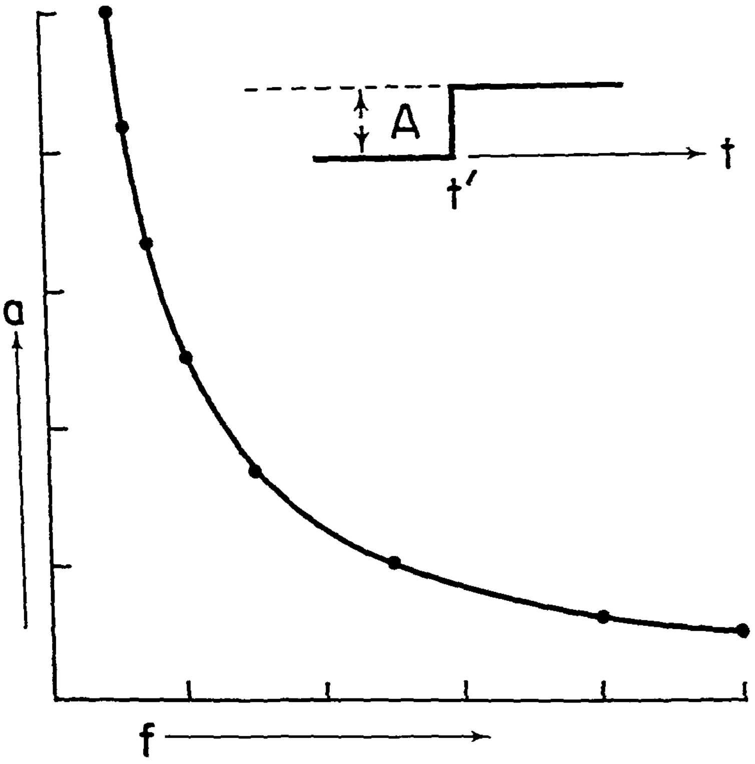

Fig 1 Band-spectrum (amplitude/cycle) of a (hypothetical) instantaneous shift in displacement amplitude The time course of the event is shown in the insert At the time t′ amplitude is instantaneously stepped up to the level A (adopted from[4])

frequencies This can be stated in a different form by saying that in case of an impulse starting gradually, the energy at a given frequency (which is much larger than one cycle) is less than it is in case of a sudden onset

The significance of impulses can be illustrated with the aid subject, slow-motion pictures (64 fr/sec) were taken of the basilar membrane in a cochlear model These models, five times the size of a human cochlea, have been described in detail in earlier papers[8] While the pictures were being taken, the "oval window" was repeatedly depressed with a finger and released either slowly or suddenly After slow depression or release, momentary displacement of the basilar membrane was seen to occur, mainly within the apical portion of the model, the bulk of the displaced fluids being exchanged through the helicotrema If, however, the depression or, because it was technically simpler to execute, the release was carried out suddenly, the displacement of the basilar membrane extended well into its middle portion The slow-motion pictures were not fast enough for an exact analysis of the pattern of these displacements, however, it is well known, from Bekesy's earliest experiments on the traveling-wave phenomena (1928),[2] that in case of a sudden stapedial displacement a single "bulge" is seen to travel along the entire basilar membrane from the window region toward the apex

To understand these model phenomena properly, a few remarks may be in order about the physical properties of sudden shifts in displacement, commonly called *impulses* Since they are not part of a continuous oscillatory event (otherwise known as "steady state" events), they are also called *transients* or *aperiodic* events Such transients, an example of which is given in Figure 1, can be examined with the aid of a Fourier analysis with respect to their frequency spectrum, as first suggested by Lord Rayleigh[7] Practical solutions were first presented by Kuepfmueller[4] In contrast to steady-state events which, depending upon their complexity, contain one or several discrete frequencies, transients have a *continuous* spectrum One might also say that the distribution of frequencies in such spectra is infinitely dense One, therefore, speaks of *bandspectra* of a given *width* The example of Figure 1 illustrates an instanteous change in displacement, an impulse of infinitely short duration Its spectrum has an infinite width, although the amplitude per cycle is not uniform It changes with frequency according to a hyperbola (see Fig 1), however, impulses like that of Figure 1 hardly ever occur in mechanical systems Usually, their time duration has cm.) are certainly not unreasonable. (Such a value may even be a little on the conservative side.) The db-ratio between both values cited is 160 db. According to what was said earlier about the spectra of impulses, this does not mean that during stapedial manipulations, amplitudes of 160 db are incurred with the frequency range of 1,500 cps to 3,000 cps,[1] where Singleton had found signs of cochlear damage.

Returning once more to Figure 2, where there are two impulses shown with the same gradual onset which is completed in the time t'. (There is a more precise way of expressing this by considering what is known as the *time constant*, a technical term which will not be discussed here.) One of these curves represents a low-level shift in displacement of say 30 db. The other is much higher and might be 160 db, as in the present case, although such differences in magnitude cannot be drawn on the same linear scale: 30 times in one case and 100 million times in the other. The point to be made is that, although both impulses have an identical spectrum, the *absolute* amplitude at a given frequency is much higher in the larger impulse than it is in the smaller one. If one assumes the amplitude in the 1,500 cps to 3,000 cps range to be −30 db *re* total amplitude of the impulse, one finds in the first case (30 db shift) 0 db *re* threshold for that range but in the second case (160 db shift) 130 db *re* threshold for the same range.

TABLE I

Amplitude eardrum (threshold)	10^{-9} cm
Amplitude stapes	2.5×10^{-10} cm
Stapedial "rocking" of ¼ mm	2.5×10^{-2} cm
R_1 - 160 db	

(Amplitude data of Bekesy)

At this time, one can only guess as to the spectra which might be incurred in stapedial displacements during mobilization procedures. Certainly, during a slow and controlled rocking motion there is no energy at 1,500 cps to 3,000 cps, however, there are two other situations which need to be considered: first, when a surgeon realizes that he has sucof a problem more familiar to otologists Similar impulses, as shown in Figures 1 and 2, are produced when a tonal signal is suddenly switched on At the onset of such a signal a click appears superimposed upon the tone In the construction of audiometers it is desirable to eliminate such clicks One achieves this simply by making the onset of the signal gradual (more like Fig 2 than Fig 1) The result is that the entire energy contained in the onset event is concentrated within the low-frequency region where it remains *inaudible*, but the point to be made is that switching transients can never be *physically* eliminated

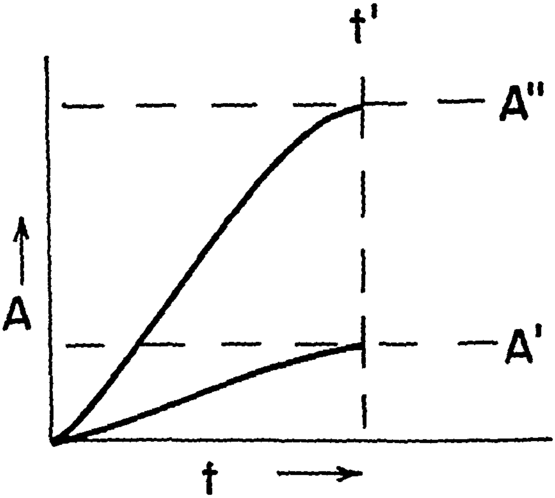

Fig 2 Time course of two (hypothetical) gradual shifts in displacement amplitude Both events are equal in time duration (t') in the pattern of the change (s-shaped) and hence in their spectrum One event (A') represents a low-level shift the other one (A'') a high-level shift

Next, the displacement amplitude which might be incurred in stapedial manipulations, must be considered in terms of amplitudes of familiar sounds Table I shows the amplitude of the human eardrum at the threshold of hearing within the ear's most sensitive range (=10^{-9} cm) From this value the stapedial amplitude has been calculated for the same condition, it is 2 5 × 10^{-10} cm , all values being given according to Bekesy's measurements[3] Assumption of stapedial displacements during mobilization procedures of ¼ mm (=2 5 × 10^{-2}

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These preliminary considerations are still based upon parameters, many of which are rather vaguely defined Before anything more definite can be said, more study is needed For one thing, the mode of response of the cochlea (or the model) to sudden impulses was left out entirely from the present consideration

SUMMARY

An attempt was made on the basis of preliminary information to account for the observation of cochlear lesions in cats after experimental stapedial fracture The attempted explanation for this observation was based upon considerations of principles of cochlear hydrodynamics

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MODERN CONCEPT OF VESTIBULAR PHYSIOLOGY[*]

PROF GOSTA DOHLMANN, (By Invitation),[†]
London, England

If we consider that it was just 85 years since Mach, Breuer and Crum-Brown, in 1874, located the sensations and reactions of rotation, on the semicircular canals, we must admit that this is a comparatively recent achievement, from a scientific point of view

The labyrinth had not attracted much attention and previously, the investigations of Fleurens, cutting and severing the canals about 1824, were unnoticed or forgotten The investigators of 1874 had known no other concept of the function of the canals than that they acted as fluid-rings, which were subjected to inertial forces in rotational head movements It was not until 1896 (about 60 years ago) that the reactions of the semicircular canals were located in the endolymph and the sensory epithelium in the ampulla, as a result of the extensive and brilliant experimental work of Ewald

At that time the existence of a cupula was denied, or it was regarded as an artifact This statement was repeated even as late as 1931 The only possible way to stimulate the hair cells of the neuroepithelium of the crista was, therefore, supposed to be by bending of the hairs in one way or the other by the endolymph stream, caused by rotational head movements Even for those who believed in the existence of a cupula, the bending of the hairs appeared still to be the important factor in the process of stimulation, even if this bending of the hairs was performed by action of the cupula One difficulty was to explain how endolymph movements, which could not be very large, *i e*, no real "streaming" of endolymph, could be able to move the small cupula inside the wide ampullae of the canals In microscopic sections the cupula appears always as a small appendix sitting on the

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[†] These investigations were made at the Institute of Laryngology and Otology London with support from the Leverhume Trustees

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crista This is due to the abundant shrinking which this jelly-like structure suffers from the action of the fixing fluids This was the situation until up to about 1930

An important step was then taken by the use of Steinhausen's method of making the cupula visible, even in the living animal This was possible by injecting into the endolymph a contrast medium such as India ink (A short film was shown which demonstrated the actual shape and extension of the cupula when uninfluenced by any chemical methods for preparation of microscopic sections)

From this it is evident that the cupula extends from the crista through the whole cross-section up to the vertex of the ampulla It is also evident that every movement of the endolymph must, therefore, be transferred to the cupula If the transmission of endolymph movements affecting a bending of the cupula has been clearly demonstrated by these experiments, there is still one important question to be settled how can the energy of mechanical bending of the cupula be transformed into the electro-chemical effect of nerve stimulation?

From the short historical survey which I have tried to present, it might seem natural that the bending of the hairs of the hair cells should be regarded as the essential mechanism for transfer of mechanical energy to the sensorial cells This is not only a labyrinthine problem, the same mechanism must be operating in stimulation of the hair cells of the cochlea and the maculae In the semi-circular canals the endolymph is assumed to bend the cupula, and the cupula, the hairs In the cochlea the basilar membrane is supposed to move up and down, and thereby producing radial movements of the upper surface of the organ of Corti with its hair cells It is further supposed that the tectorial membrane rests loosely over the organ of Corti, that it should be relatively stiff so that the free endings of the hairs should be bent outwards and inwards when the hair cells of the organ of Corti are vibrated by the movements of the stapes

The tectorial membrane, however, is of the same jelly-like nature as the cupula, and it seems to me rather strange to suppose that this jelly should have a rigidity greater than the moving cochlear partition of basilar membrane and cells

Further, it is beyond doubt that the histological picture of the tectorial membrane, as a free floating formation over the organ of Corti, attached only to the limbus is an artifact, due to the shrinking agents necessary for the fixing and preparation of the histological sections, just as the cupula always shrinks to only a part of its natural size as seen in all microscopic sections

It has been shown by Anderson Hilding, in fresh preparations, and in frozen dried sections by deVries, that the tectorial membrane is fixed on either side of the organ of Corti, which means that the tectorial membrane is attached to the whole upper surface of the organ of Corti with its hair cells and hairs This is easily proven by anybody who can use a dissecting microscope and a preparation needle

In 1954 Vilstrup and Jensen showed the presence of hyaluranic acid in the endolymph of Acantias, and Jensen, Koefoed and Vilstrup showed that potential changes could be produced in hyaluranate solutions on displacement of the fluid Vilstrup suggested that these "flow potentials" could be of importance for the stimulation of the sense organs of the ear

As is well known, electrical potentials can be led off from the cochlea, potential changes, synchronous with the sound waves of tones transmitted to the ear, can be recorded This is what is meant by the Wever and Bray effect, or cochlear microphonics If the basilar membrane and the organ of Corti is pushed upwards from the scala tympani, this gives a potential change in the negative direction which lasts as long as the displacement lasts, and if the movement is performed in the opposite direction this will give an increased positivity This apparently means that a displacement gives a potential change of a D C type, and that rapid changes of displacement gives an A C response Exactly the same happens if the electrical changes are led off the ampulla If the cupula is moved in one direction one change can be recorded, *e g*, in a positive direction; if the cupula is bent in the opposite direction, the potential change is reversed, and further, rapid potential changes can be recorded if the cupula is exposed to a tone stimulus when a fistula is made in the canal crista This is due to the abundant shrinking which this jelly-like structure suffers from the action of the fixing fluids This was the situation until up to about 1930

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After two hours there are more silver grains in the epithelium, and after four hours the irradiation has produced a very dense black ribbon over the epithelium and nowhere else to the same extent

After six hours there is still a dense blackening, after 18 hours the intensity is slightly decreasing After 24 hours there is only an insignificant irradiation, which means that all the labelled sulphur has passed through the epithelium into the endolymph cavity

The shrunken cupula shows no irradiation after one hour nor after two hours The irradiation from the cupula is insignificant after four hours, slightly greater after six hours At 24 hours, at the time when most of the radioactive sulphur has left the epithelium, the irradiation from the cupula is dense, as are also the clouds of coagulated endolymph which can be seen inside the membranous canal After three or four days the irradiation from the cupula and endolymph again decreases

We have followed the fate of this radioactive compound up to 30 days after injection This investigation shows that the radioactivity in the clouds of coagulated endolymph decrease, and disappear after five to ten days, that the activity in the cupula also decreases but can still be observed to some extent, even after 30 days, further, it is possible to follow the excretion of the radioactive granules, which definitely pass through the ductus endolymphaticus (S Guild) are condensed there into a thrombus-like coagulum and pass through the saccus endolymphaticus into the loose connective tissue surrounding this tube, and apparently are excreted into the cerebrospinal fluid through a structure with finger-like processes resembling the chorioid plexus in the ventricles of the brain

Expressed in chemical phraseology, this would means that the secretory epithelium builds up and secretes sulphur-bound compounds, which, when secreted by an epithelium like this, should be sulpho-muco-polysaccharides In order to confirm

How can these facts be brought in accordance with the historical conception of a bending of the hairs as the mechanism for transmitting of the mechanical movements into these known electrical effects? Is there any example of a living tissue which can give an effect like this, giving a positive potential change in one direction when bending a hair, and negative when bending the same hair in the opposite direction, or is it even probable?

It is known that the potential changes of the cochlear microphonics are sensitive to oxygen deficiency and to certain poisonous substances which are supposed to be transmitted to the hair cells from some secretional epithelium over the endolymph, therefore, it seemed pertinent to study the mechanism of endolymph secretion to see whether some information could be obtained which would be of value in the interpretation of the mechanism of stimulation

For several reasons it seems probable that mucopolysaccharides played an important role in this metabolism The radioactive isotope of sulphur S 35 was, therefore, chosen as a tracer We have used pigeons for these experiments

To be able to explain the results of our experiments, I must explain the technique The labelled isotopes are injected intramuscularly, the birds are killed after different periods of time from one hour to 30 days Serial sections are prepared from the inner ear These microscopic sections are covered in the dark with a layer of photographic film The sections are then stored, still in the dark, for some length of time, thus exposing the film to the radiation from the radioactive parts of the tissues When developed the film showed the exact distribution of the sulphur compounds, due to the metabolic processes The results of these investigations will be apparent from the slides The first slide is a cross-section of the ampulla from a pigeon killed four hours after the injection It shows exposed silver grains over the epithelium of the sidewalls of the ampulla, the region which is called planum semilunatum

If we look at this epithelium in pigeons kept alive for different periods after injection, we can ascertain the time required for the labelled molecules to participate in the metabolic processes and pass through the different tissues and fluids of the inner ear After one hour these can be seen in the film as a few scattered silver grains

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If we look at this epithelium in pigeons kept alive for different periods after injection, we can ascertain the time required for the labelled molecules to participate in the metabolic hand, the movements were very small, such a mechanical stimulation of the hair cells would be impossible, and the assumed fluid movements in the cupula could then be of greater importance in the explanation of those phenomena in the inner ear to which we will refer later An experiment was made to determine the cupula deflections due to forced fluid movements through a fine canula cemented into an opening in the canal wall This experiment showed that even with movements which could give a deflection of at the most, half a degree of arc, unmistakable vestibular reactions were recorded This would mean that the tip of the hair could not have been moved more than 0 3 μ, probably less

Turning then to the hair cell, it is known from the electron-microscopic studies of these cells by Wersall, Catherine Smith and others that there are about 50 to 60 hairs extending from each cell, they are about 40 μ long and 0 2 μ in diameter. They have a central fibrillary structure only in the basal part of about 4 μ in length These 4 μ in the basal part of the hair could theoretically be regarded as a stiff part which possibly could react to a bending, whereas the distal 9/10 of the hair would be totally flexible, furthermore, the basal part of the hair just passes through the cuticle of the cell, but never shows any continuation down into the cytoplasm of the cell Morphologically, therefore, this picture does not seem to support the assumption of a stiff strictuie which would be able to stimulate the cell by bending of the hair

According to the electron-microscopic picture, the hair seems thus to be built up of a finely granulated protoplasma with a thin outer plasma membrane, and that this membrane is the continuation of the plasma membrane of the cell, therefore, the hairs of the hair cells must be regarded as long, tube-like extensions of the cell-surface, giving a considerably enlarged surface area of the cell The cell surface (except hairs) can be estimated at about 40 to 50 μ^2 but with the surface of the hairs the total area will amount to between 3,000 and 4,000 μ^2 This seems to be a very important fact, because if we consider that these hairs protrude out into the cupular substance lying in fine canals, and that this cupular meshwork is soaked through with a secretion containing two important constituent parts, the sulpho-mucopoly- sac-this assumption, and to investigate which compounds are coupled to the sulphur, together with Dr H Bostrom, I have collected endolymph from pigeons injected with S 35 and by means of electrophoresis and chromotography, examined the chemical content of the fluid So far this has only confirmed that the organic compounds are protein-bound sulpho-mucopolysaccharides, but further investigations are planned

Anatomically, the distribution of the secretory epithelium has been found to embrace the cupula from both sides, and to continue on the utricular as well as the canalicular side, thus totally enclosing the neuroepithelium with its cupula

From a functional point of view it would be astonishing if the secretion of such complex compounds into the cupula and then into the endolymph, were not of some fundamental significance to the physiological function of the mechanism located in the ampulla

To discuss this fundamental question we must consider some facts about the cupula It is generally assumed that the cupula is built up as a meshwork or sponge It is apparently in this meshwork that one finds the mucopolysaccharides It is also generally accepted that the hairs of the hair cells lie in fine canals in the cupula substance

If a very small drop of a dye is deposited in the cupula it is possible to see the dye particles moving longitudinally up and down, if the cupula is moved by some external force

Accordingly, these two observations would suggest that bending or pressure on the cupula could produce fluid movements in the cupula meshwork and in the fine canals around the hairs of the hair cells With regard to the shape of the cupula fixed to the surface of the crista, as it is, one would have reason to expect the fluid in these small canals to move in one direction with an ampullo-fugal displacement of the cupula, and in the opposite direction with an ampullo-petal deflection of the cupula This is an assumption, and I will leave it as such at the present moment

If the movements of the cupula at the threshold must be extensive before the neuroepithelium could react, then this would speak in favor of some mechanism which could bend or tear the hairs or even deform the cells If, on the other hand, the movements were very small, such a mechanical stimulation of the hair cells would be impossible, and the assumed fluid movements in the cupula could then be of greater importance in the explanation of those phenomena in the inner ear to which we will refer later An experiment was made to determine the cupula deflections due to forced fluid movements through a fine canula cemented into an opening in the canal wall This experiment showed that even with movements which could give a deflection of at the most, half a degree of arc, unmistakable vestibular reactions were recorded This would mean that the tip of the hair could not have been moved more than 0 3 μ, probably less

Turning then to the hair cell, it is known from the electron-microscopic studies of these cells by Wersall, Catherine Smith and others that there are about 50 to 60 hairs extending from each cell, they are about 40 μ long and 0 2 μ in diameter They have a central fibrillary structure only in the basal part of about 4 μ in length These 4 μ in the basal part of the hair could theoretically be regarded as a stiff part which possibly could react to a bending, whereas the distal 9/10 of the hair would be totally flexible, furthermore, the basal part of the hair just passes through the cuticle of the cell, but never shows any continuation down into the cytoplasm of the cell Morphologically, therefore, this picture does not seem to support the assumption of a stiff structure which would be able to stimulate the cell by bending of the hair

According to the electron-microscopic picture, the hair seems thus to be built up of a finely granulated protoplasma with a thin outer plasma membrane, and that this membrane is the continuation of the plasma membrane of the cell, therefore, the hairs of the hair cells must be regarded as long, tube-like extensions of the cell-surface, giving a considerably enlarged surface area of the cell The cell surface (except hairs) can be estimated at about 40 to 50 μ^2 but with the surface of the hairs the total area will amount to between 3,000 and 4,000 μ^2 This seems to be a very important fact, because if we consider that these hairs protrude out into the cupular substance lying in fine canals, and that this cupular meshwork is soaked through with a secretion containing two important constituent parts, the sulpho-mucopoly- sac-charides and potassium, then I believe that we have the right to presume that this is an arrangement which can be described as, *1* an insulated entity of electrically leading solutions, the cell, *2* this cell sends out a great number of antennas, the hairs, into a *3* highly charged electrical field—the solution in the cupular meshwork

We know that in a solution of mucopolysaccharides and electrolytes, the very large and highly negatively-charged molecules of the polysaccharides are binding the positive electrolyte-ions of potassium to its surface This means that as long as no physical changes are imposed on this mechanism, the positive and negative charges are kept in balance, however, as soon as movements are imposed on the fluid, the positive potassium-ions, which are more movable, will move in the direction of the fluid displacement and leave the slow polysaccharide molecules behind This means that the antennas of the hair cells, surrounded as they are by these molecules and moving ions, are, on their surfaces, exposed to the electrical charges which are predominant at that moment Moving the fluid then in a direction toward the hair would mean an increased positive, a movement in the opposite direction, increased negative We also know that the potassium content in the endolymph is about the same as in the interior of the cell, and that the endolymph is positive with regard to the potential of the hair cells This high concentration of potassium and the high potential difference between the outside and inside of the hairs and the cell is a very remarkable fact If a potential change at the cell's or hair's plasma membrane should give an increased permeability of that membrane, it would be totally disastrous to the cell, because if the positivity is increased outside the cell this cell would immediately be overloaded with potassium, to an extent inconsistent with life Second, it would be impossible for the cell to work against the high concentration gradient of potassium and against the electrical gradient between cell and endolymph even if the electrical charge is slightly lowered or raised around the hairs Already, from the fact that these two gradients are a constantly present potential danger to the cell we might presume that the plasma membrane that shields the cell from the surrounding fluid in the cupula is *impermeable*. This is not a common thing, but is by no means unique

This implies that the cell works as a condenser, a positive charge applied outside the insulating membrane gives a negativity to the inside salt solutions of the cell protoplasm, and vice versa

This might further explain the facts of a standing and remaining potential value in the cell due to a certain mechanical displacement, *e g*, of the cupula or the basilar membrane, and it explains the rapid potential changes like those of the cochlear potentials, and above all, makes it possible to explain a function capable of moving in both directions, positive and negative, from the position of a resting cell-potential This has not been possible to explain through the hypothesis of the bending hairs This might also well fit in with some other known investigational results

For instance the observations on the cochlea, by Hallowell Davis and his collaborators, by Békésy and others, have indicated that the source of the potential changes due to the mechanical stimulation is at the hair-bearing end of the hair cells and orientated perpendicularly to the cell surface This cannot possibly be explained in any other way than through a condensor effect at the cell membrane of the hair cells

Further, there is another experiment of Davis, et al, which is of interest in this connection Recording the cochlear microphonics through a microelectrode, which was slowly moved from the endolymphatic cavity in the cochlear duct into a hair cell in the organ of Corti, Hallowell Davis could show that in the moment the electrode passed through the cell membrane which was proven by the sudden potential drop from about +60-90 mv to about –70 mv, there was an equally sudden phase shift in the electrical response to the sound-waves of the test tone This means that when the mechanical movements of the cochlear fluids by an inward movement of the stapes, gave a potential change in the positive direction, this then became negative in the cell, and vice versa, a condensor effect

Considering the situation in the cochlea, we learn from every textbook that the movements of the basilar membrane charides and potassium, then I believe that we have the right to presume that this is an arrangement which can be described as, *1* an insulated entity of electrically leading solutions, the cell, *2* this cell sends out a great number of antennas, the hairs, into a *3* highly charged electrical field—the solution in the cupular meshwork

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In conclusion, I confess my belief in this situation of conflict with current doctrines, which I have deliberately been stirring up

I think I would rather believe that some little devil, sitting on the crista, directs the stimulation one way or another, than to believe that a bending of a hair would be able to produce a cell stimulation in one direction and that the bending of the same hair in the opposite direction could give the opposite response, unless somebody could explain to me this miraculous phenomenon in plain words based on known and undisputable facts

What I really believe is that, whatever mechanism might be operating, it must have the ability both to increase and to decrease the cell potential of the hair cell Taking into consideration the electrical possibilities of the endolymph solutions—mucopolysaccharides and potassium—I believe that they are most likely to be the source of electrical changes, working on the membrane of the hairs and cells the same way as a condensor works are of prime importance for the function of the cochlea, and that these movements are transformed into rocking movements of the organ of Corti, which in this way rubs its surface against the supposedly stiff tectorial membrane, thus explaining the bending of the hairs of the hair cells

It has been pointed out that the first condition for a transformation of the up-and-down movements of the basilar membrane into movements in a radial direction is that the inner pillar has a firm support on the tip of the bony spiral lamina This is the case in the guinea pig, but not in man In the human ear the organ of Corti is situated on the cochlear partition halfway between its two supporting points at the spiral lamina and the spiral ligament The result is that the movements of the hair cells can be expected to occur only in the directions up-and-down, and only to a very small extent in any other direction These movements could not possibly promote bending of the hairs in the traditional way of thinking Besides these objections, I would remind you of the calculations of Békésy regarding the magnitude of the movement of the basilar membrane, which at threshold level could not be expected to exceed the diameter of a hydrogen atom

This microscopic section of the pigeon's cochlea, shows the hair cells supported by a massive cushion of connective tissue which does not facilitate a vibration in the traditional sense, and still I believe that the cochlea of the pigeon, as well as that of man, is the organ of hearing, therefore, I think that it is much more important to note what actually can happen to the tectorial membrane, than to the movements of the basilar membrane There is no doubt that the basilar membrane can move and that it moves in the way Békésy has so beautifully shown in his experiments, but I am quite convinced that this is of secondary importance to the movements in the substance of the tectorial membrane with the possibilities this can give for rapid changes in electrical potentials at the surface of the hairs

Nobody has suggested that the crista in the semicircular canals should be the moving part against a stiff cupula, or explained the stimulation by rotational head movements, or explained the response to tones in the Tullio-fistular-experiment, therefore, I believe that it is necessary to judge the function of these very important jelly-like structures from a unitary point of view, the manner in which the cupula functions in the semicircular canal in response to endolymph movements, as well as to tones, cannot be fundamentally different from the functional mechanism of the tectorial membrane or the otolith membranes With small differences according to their use for special mechanical purposes, it is most likely that they function in principally the same way

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IMPROVEMENT OF SOUND TRANSMISSION IN THE FENESTRATED EAR BY THE USE OF SHEARING FORCES *†‡

JULIUS LEMPERT, M.D.,
and
GEORG V BÉKÉSY, Ph.D ,

New York, N Y.

Earlier studies of the sound transmission from the ear canal to the organ of Corti made it clear that the transmission is done in two separate steps In the first step the vibrations of the air are transmitted to the perilymph, a fluid To avoid energy loss during this transmission the well-known middle ear mechanism is used as a transformer to match the air-fluid boundary In the second step, the movements of the perilymph are transmitted to the cells of the organ of Corti, a more-or-less solid material To avoid the energy loss in this transmission from a fluid to an elastic membrane a second transformer is used The first mentioned transformer in the middle ear is of the type of the hydraulic press and is well known The second transformer in the organ of Corti, however, is something new It is a transformer based on shearing forces described by Bekesy in the *Journal of the Acoustical Society of America* This new finding by Bekesy naturally gave rise to the following question "Can a shearing force transformer be used to improve, in the fenestrated ear, the transmission of the air-borne sound to the newly created covered extratympanic vestibular fenestra?"

How a shearing transformer acts may be seen in the upper drawing of Fig. 1 This figure shows the cross-section of a membrane stretched across the edges of an open tube In the middle of the membrane, a small single force is applied as illustrated by the small arrow As a consequence of this

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*Read at the Meeting of the Eastern Section of the American Laryngological Rhinological and Otological Society New York, N Y Jan 9 1959

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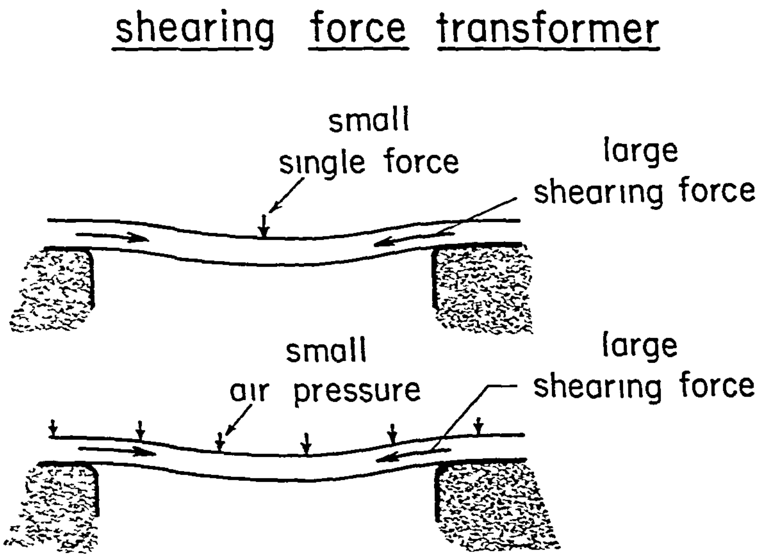

Fig 1 The upper figure shows that a small single vertical force can produce a large horizontal shearing force The lower figure shows the same action for a small air-pressure

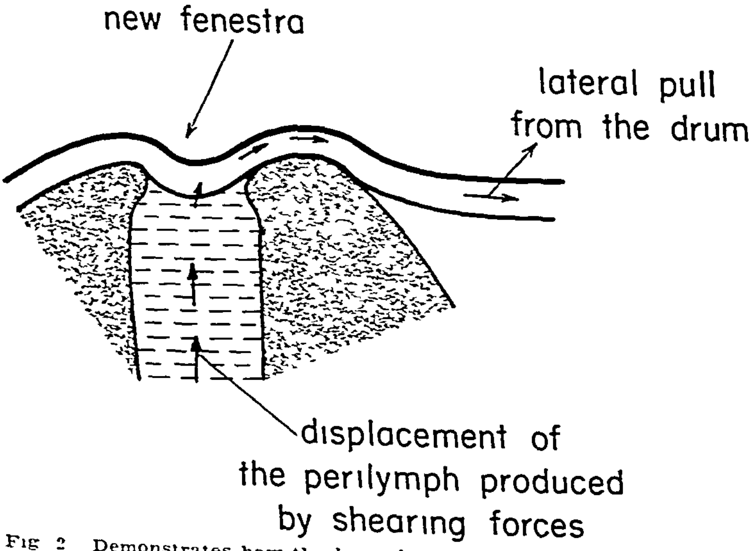

Fig 2 Demonstrates how the large lateral shearing force displaces the perilymph below the fenestra

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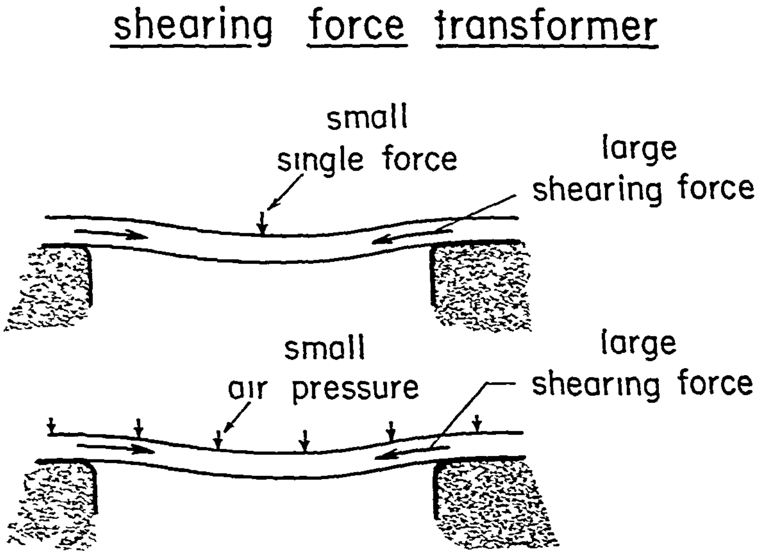

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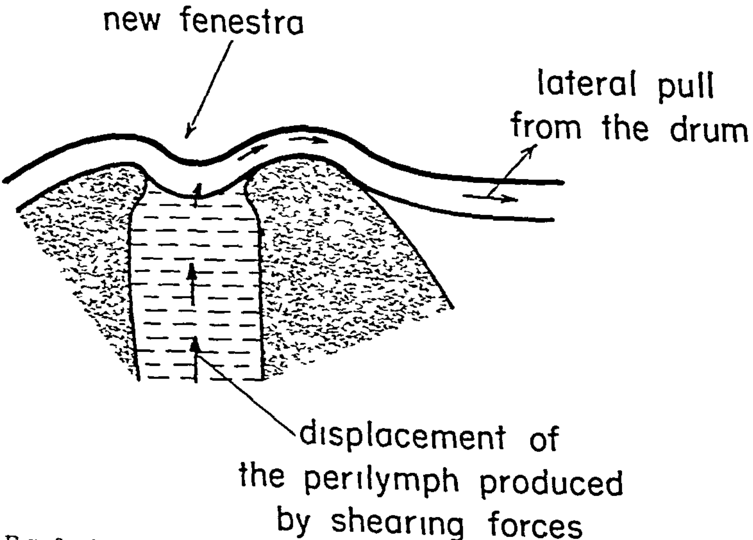
new fenestra
lateral pull from the drum
displacement of the perilymph produced by shearing forces

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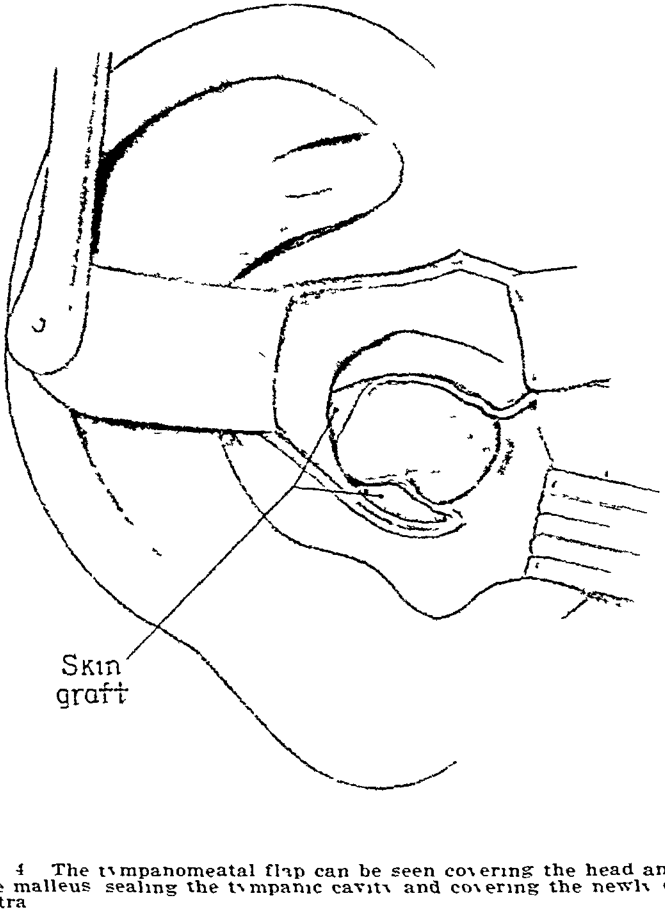

Fig 4 The tympanomeatal flap can be seen covering the head and neck of the malleus sealing the tympanic cavity and covering the newly created fenestra

relative to the attached lower surface. This gliding motion of the upper surface in relation to the fixed lower surface is called "shearing" Depending on the thickness of the membrane the forces produced on the surface are somewhat smaller than the entire lateral pull on the edges of the tube, but they may act as a force increase in relation to the central force

Not only a single central force but also an evenly distributed pressure on the entire upper surface of the membrane pro-

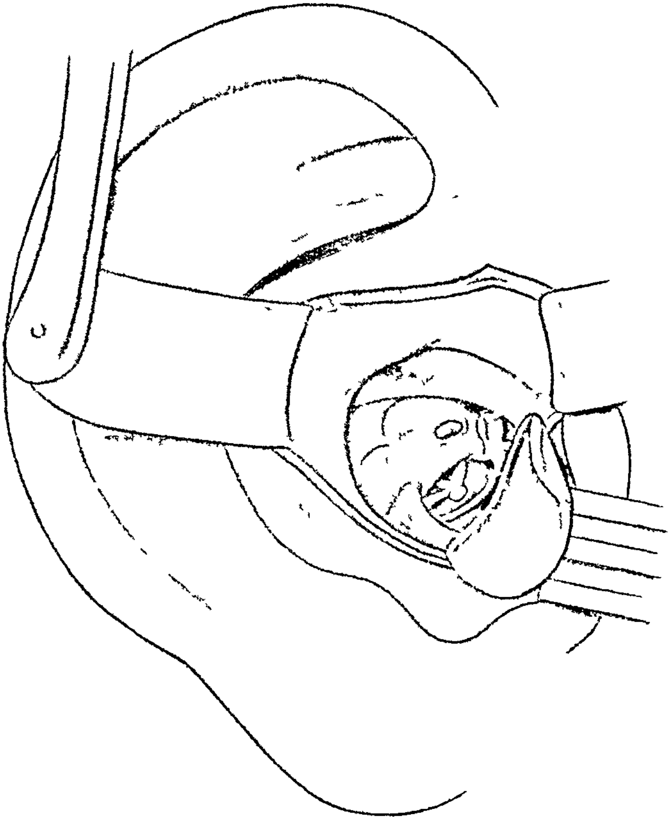

Fig 3 The incus has been removed The tympanomeatal flap has been created Exposed to view are the newly created fenestra in the surgical dome of the vestibule, the tympanic course of the facial nerve canal the head and neck of the malleus with its ligamental attachments the chorda tympani nerve and the head and crura of the stapes

small force, considerable stress is developed on the edges of the membrane This force is larger than the force applied in the center, therefore, the system represents a transformer for forces which increases a small force to a larger one similar to a lever

The lower surface of the membrane is attached to the edge of the tube (as seen in the drawing) and only the upper surface of the membrane will be displaced in a gliding movement the lateral pull of the eardrum is transmitted to the perilymph, produced by the force transformation, as shown in Fig 1

If the application of the shearing force transformer is successful and functions as a transformer, then the force acting on the perilymph as a consequence of the shearing force is larger than the simultaneously-present sound pressure on the window In this case phase relations between the direct sound pressure on the window and the shearing force produced by the sound pressure on the eardrum are not important when we add the two tones together

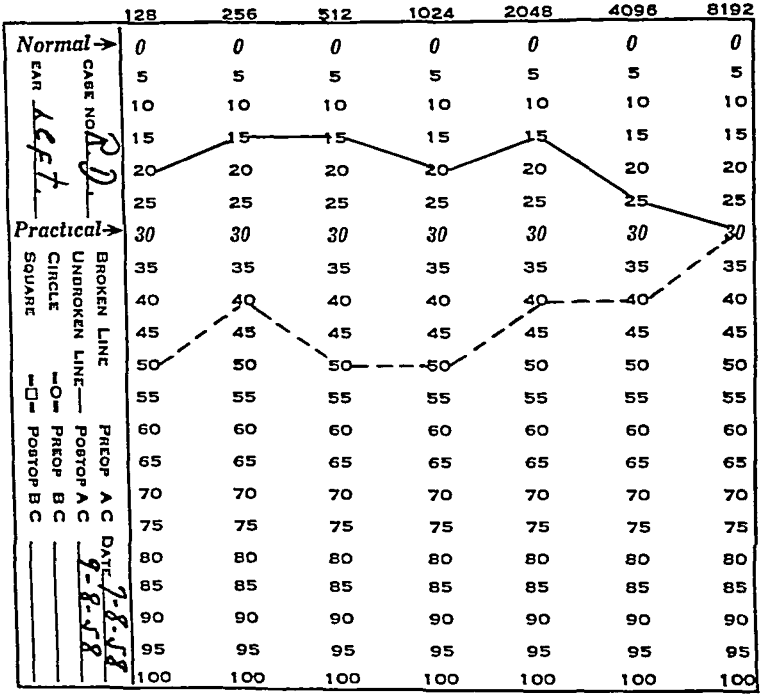

Fig 6

Experiments on models and on the operating table have shown that a shearing force transformer can be a very useful method Since the physical part of the method seemed to promise the desired results, we are now working on the biologduces a strong lateral pull and a corresponding shearing force on the upper surface of the membrane The action of the air pressure is shown in the lower drawing of Fig 1

Fig 2 shows how the lateral pull on the edge of the membrane is transmitted by shearing forces to the perilymph in the newly formed fenestra As can be seen, a section of the

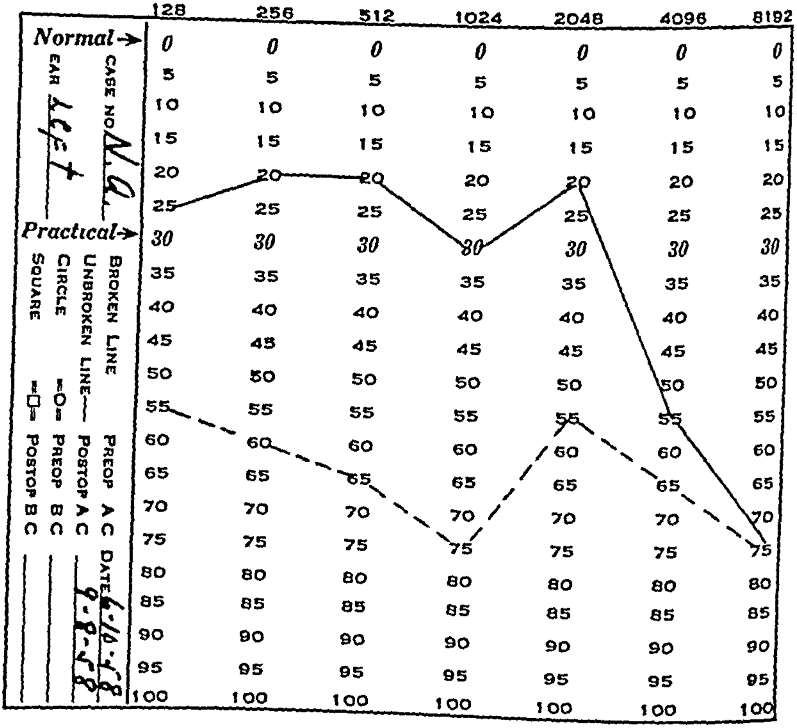

Fig 5

lower surface of the membrane is firmly attached to the bony wall of the canal, but the upper surface of the membrane glides freely over the bony edges and will transmit a pulling force on the window membrane if it is properly invaginated

Here again the thickness of the flap, the size of the window, the length of the attached section of the flap, tension of the eardrum, etc, all play an important role in determining how the lateral pull of the eardrum is transmitted to the perilymph, produced by the force transformation, as shown in Fig 1

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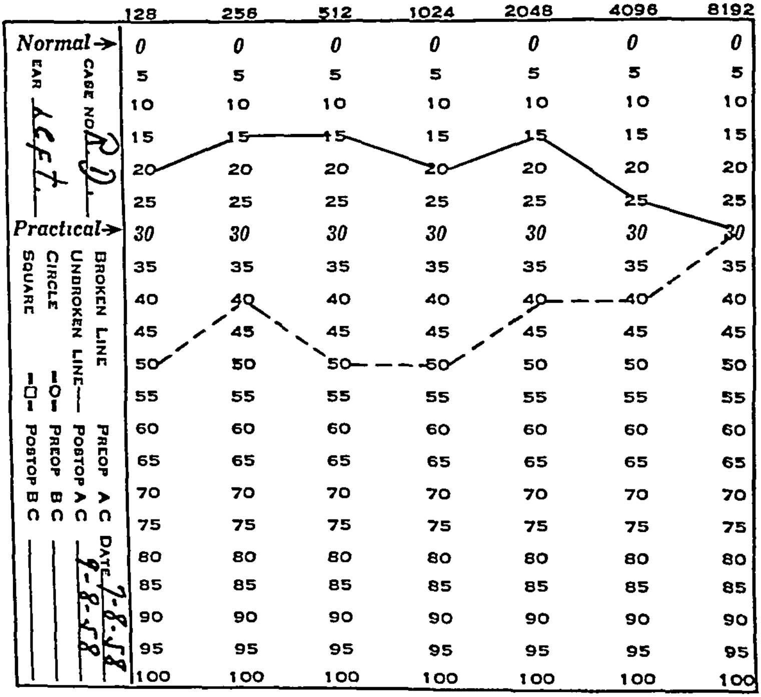

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Experiments on models and on the operating table have shown that a shearing force transformer can be a very useful method Since the physical part of the method seemed to promise the desired results, we are now working on the biological side of the question, namely, how the shearing force transformer should be constructed from the living tissues of the middle ear so that the mechanical construction fits most naturally the biological conditions of the human middle ear We think that in general this problem has been basically

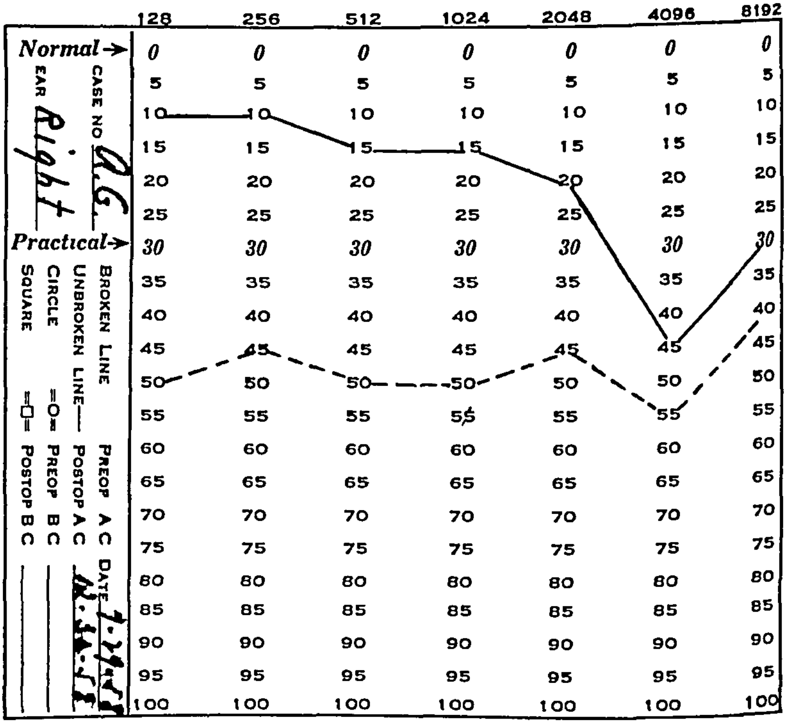


Fig 7

solved with the use of the malleus and the tympanomeatal flap for creating the shearing force transformer

Figs 3 and 4 show the technique of creating the shearing force transformer (see Figs 5, 6, 7, 8)

We shall report the technique minutiae after we have had sufficient time to follow up the patients Then we would also like to report, in greater detail, the physical principles of the shearing force transformer upon which this new technique is

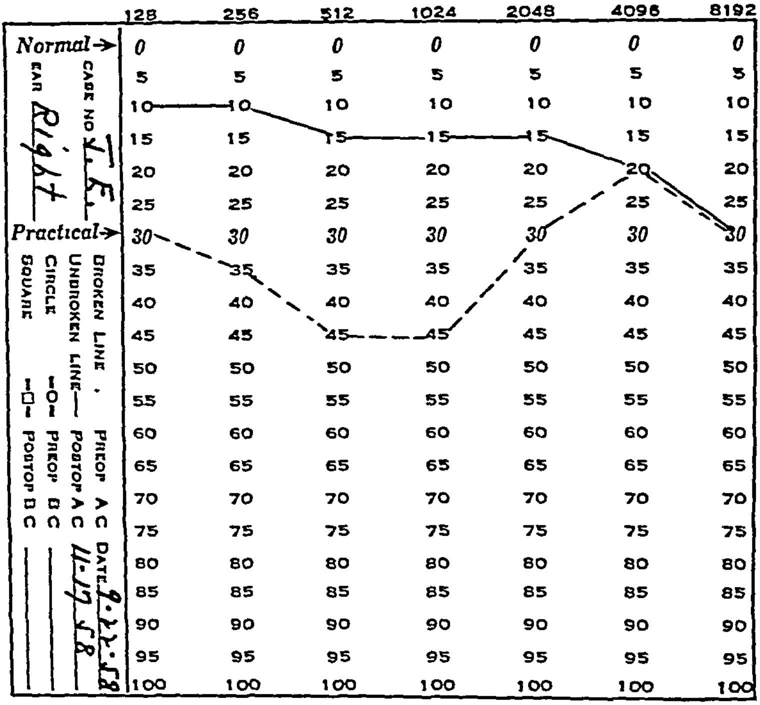
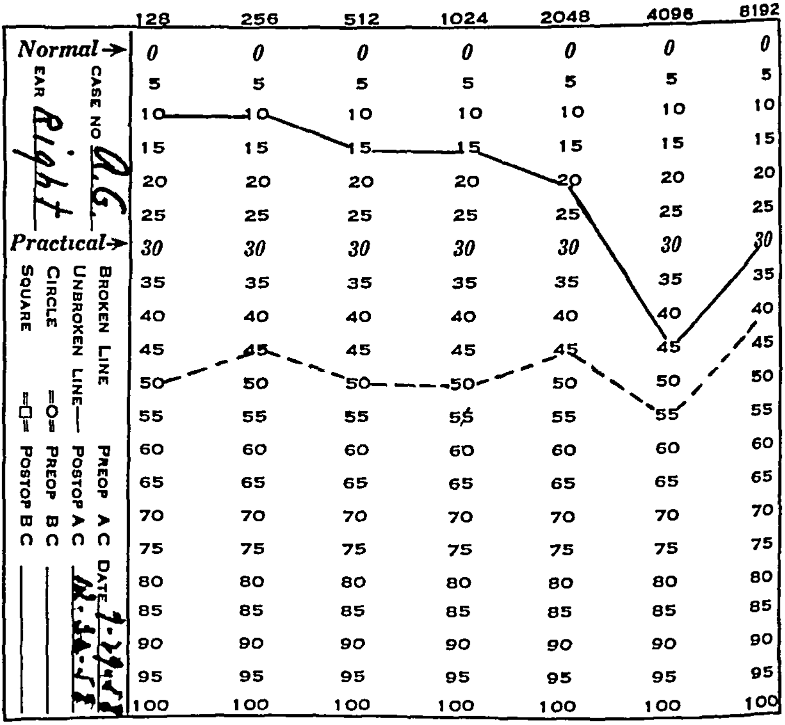


Fig 8

based, as well as the specific method of approach to the problem of deliberately and consecutively improving the hearing to the near normal and, if possible, to the normal level following the fenestra nov-ovalis operation.

ELEVENTH CONGRESS OF THE INTERNATIONAL ASSOCIATION OF LOGOPEDICS AND PHONIATRICS

Those unable to attend this Congress but who would like to secure a copy of the Report of the Proceedings can obtain it at the reduced rate of *seventeen shilling and sixpence* (17/6) by ordering it in advance, enclosing payment, from the Secretary, before August, 1959 Secretary's address Peggy Carter, L C S T , 46 Canonbury Square, London, N 1 ical side of the question, namely, how the shearing force transformer should be constructed from the living tissues of the middle ear so that the mechanical construction fits most naturally the biological conditions of the human middle ear We think that in general this problem has been basically



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We shall report the technique minutiae after we have had sufficient time to follow up the patients Then we would also like to report, in greater detail, the physical principles of the shearing force transformer upon which this new technique is only 18 per cent of successful results in these cases of bi-crural otosclerosis, as compared to 89 per cent with anterior footplate otosclerosis In a recent 100 mobilizations, we have performed central repositioning of the footplate in 19 cases with 80 per cent of these obtaining a worthwhile hearing improvement at the one-month audiogram In many of these cases, the otosclerosis was so extensive as to be considered almost inoperable This improvement of results in cases of bi-crural otosclerosis has encouraged me to make this preliminary report on crural repositioning Dr Bruce Proctor[12] has encouraged me to make this report, stating that he knows of no similar technique reported in the literature

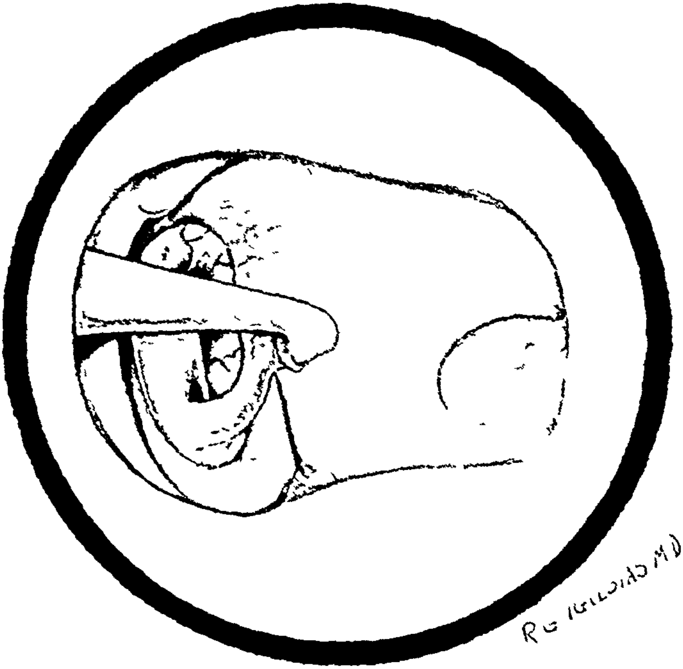

Fig 1 Crural otosclerosis is the greatest cause of refixation after total stapes mobilization Bi-crural otosclerosis occurs in about 20 per cent of cases and requires special surgical technique for lasting results crural repositioning is advocated

CRURAL REPOSITIONING IN STAPES MOBILIZATION SURGERY *†

J Brown Farrior, M D ,

Tampa, Fla.

INTRODUCTION

Crural otosclerosis is, in my opinion, the greatest cause for failure and refixation after total mobilization of the stapes by the Rosen[1] or other[2,3,4,5,6,7] indirect or direct surgical attacks upon the stapes Fowler[9] has made a great contribution to the lasting results of stapes surgery by removal of the anterior crus and mobilization of the posterior footplate and crus This anterior crurotomy has given us the greatest per cent of cases with complete closure of the air-bone gap, and of lasting hearing improvement in anterior crural otosclerosis There remains, however, the problem of the surgical attack when the otosclerotic lesion involves both crura In bi-crural otosclerosis, I have had significant success with central repositioning of the posterior crus, accompanied by anterior crurotomy, tendonotomy and central footplate mobilization

In a review of our photo-pathological slides on the stapes, Farrior[10] reveals that about 75 per cent of cases have otosclerotic lesions localized to the anterior footplate or anterior crus These respond to total stapes mobilization or to anterior crurotomy There are about 20 per cent of the cases with bi-crural otosclerosis, and an additional 5 per cent with more extensive disease showing complete involvement of the footplate or obliterating lesions of the oval window niche This paper will deal with that most interesting 20 per cent of the cases which have bi-crural otosclerosis

With the total mobilization technique, we initially obtained

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*Read at the Meeting of the Southern Section of the American Laryngological Rhinological and Otological Society Atlanta Ga Jan 23 1959

†Presented as a part of Interesting Ears in 3-D Southern Section American Laryngological Rhinological and Otological Society Inc Atlanta, Ga Jan 24 1959

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TENDONOTOMY

The section of stapedious tendon is usually removed with the Bellucci scissors (see Fig 2-a) If the exposure or the length of the tendon does not permit the use of the scissors, the tendon is sectioned with the sickle knife and the eminence removed with the curette It is important to remove a section of the tendon to prevent postoperative fibrous union and subsequent limitation of the mobility of the stapes

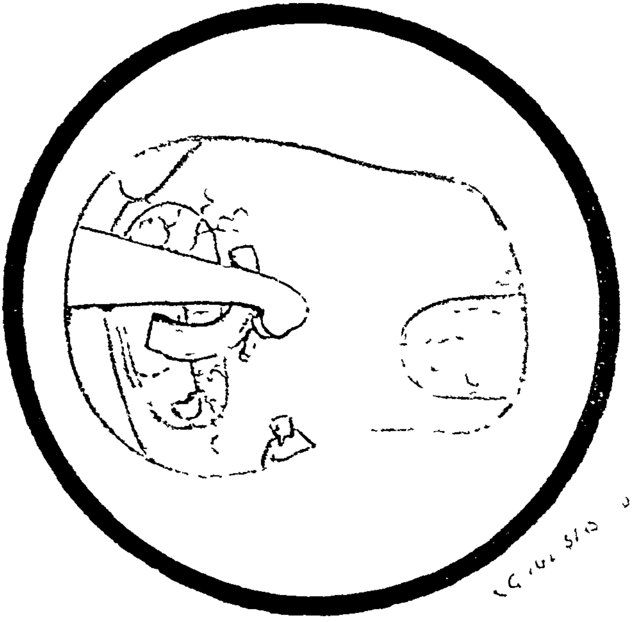

Fig 3 The completed posterior crural repositioning demonstrates the posterior crus in position over the mobilized impacted central area of the footplate to which it bcomes adhered by fibrous union

POSTERIOR CRURAL FRACTURE

The posterior crus is then fractured away from the otosclerosis as near as possible to the footplate, in order to obtain

SURGICAL TECHNIQUE

Adequate exposure of the stapes and stapedius tendon is obtained through the exposure of the operator's choice (see Fig 1) A section of the stapedius tendon is removed for accurate microscopic diagnosis of the posterior crural otosclerosis and to obtain greater mobility of the stapes (see Fig 2-a) Having established the diagnosis of bi-crural otosclerosis with a reasonable central area of normal or near-normal footplate, I then proceed with the stapes surgery by fracturing the posterior crus away from the otosclerosis (see Fig 2-a), second, an anterior crurotomy is performed (see Fig 2-b), third, the central area of the footplate is mobilized (see Fig 2-c), and fourth, the posterior crus is moved forward to approximate this central area of mobilized footplate (see Figs 2-d, 3)

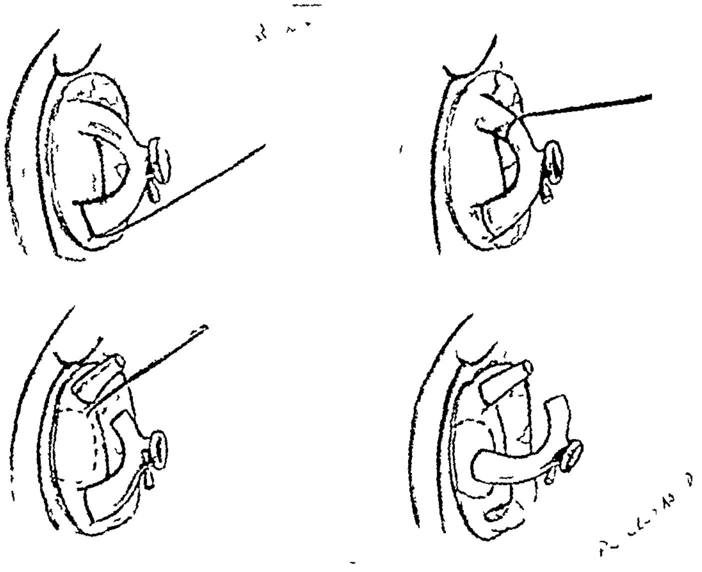

Fig 2 Crural repositioning has given us improved results in bi-crural otosclerosis The steps in surgical technique are 1—2-a Tendonotomy and posterior crural-lysis, 2—2-b Anterior crurotomy 3—2-c Central mobilization of the uninvolved footplate 4—2-d Central repositioning of the posterior crus

courage postoperative fibrous union with the cut end of the posterior crus

FOOTPLATE MOBILIZATION

In bi-crural otosclerosis, the anterior, posterior and inferior margins of the footplate are usually fixed in the otosclerotic process, (superior bi-crural otosclerosis is similar but rare, less than 1 per cent) There is usually a central area of normal or near-normal footplate This central area of the footplate is mobilized with the pick or chisel I prefer to impact this central area in order to insure a freely movable non-bony healing of the margins of the mobilized trap door in the footplate

CRURAL REPOSITIONING

The freely movable posterior crus is then swung forward to approximate this mobilized central area of the footplate (see Figs 2-d, 3) The freely movable posterior crus will usually maintain its position in contact with the central area of mobilized footplate This contact is encouraged by gentle pressure on the incus In rare circumstances, it has been necessary to insert gelfoam behind the crus to maintain this central repositioning of the posterior crus

In only one instance has the anterior crus been longer than the posterior crus In this instance, the anterior crus was repositioned in a similar manner

ARTIFICIAL CRURA

At one time I made the statement that "bi-crural otosclerosis is beyond the limits of present day mobilization surgery" (Farrior[14]) From this point I began to develop the above-described technique This technique was at first utilized only in the far advanced cases which were beyond the limits of fenestration surgery I now utilize, or attempt to utilize, this technique in cases of bi-crural otosclerosis with a wide oval window niche

Central repositioning at the posterior crus is, to me, preferred to the use of the artificial crura, simply because I do the longest available section of the posterior crus. Posterior crural-lysis is performed by wedging a pick or chisel between the posterior-inferior margin of the oval window and the posterior crus It is important to fracture the posterior crus before performing the anterior crurotomy, otherwise the posterior crus may fracture near the neck and be too short If there is some doubt about the diagnosis of the posterior-crural otosclerosis, the efforts about the posterior crus are directed first toward an attempt to mobilize the posterior half of the footplate If the posterior crus is found to be free, this mobilization is continued, and subsequently the anterior crurotomy is performed In anterior-crural otosclerosis, Shea[13] prefers to mobilize the posterior footplate and crus before performing the anterior crurotomy in order to avoid posterior crural fracture

ANTERIOR CRUROTOMY

The anterior crurotomy is one of the most valuable and difficult techniques in all of stapes surgery I usually approach the anterior crus with the chisel or gouge Where possible, the curved chisel or gouge is inserted over the top of the incus and the force directed in the long axis of the anterior crus By scraping on the anterior crus, the shaving technique usually sections the crus If the anterior crus cannot be sectioned by manual control, the end of the chisel is touched with the micro-vibrating sides of the forked end of the 256 or 512 magnesium tuning fork

Sometimes it is necessary to approach the anterior crus from behind the incus, under which circumstances similar maneuvers are directed toward sectioning the anterior crus

The stump of the anterior crus is then folded forward with a right angle pick This right angle pick also serves to make certain that a portion of the anterior crus has been removed Fowler advocates removal of a section of the crus to prevent post-operative reunion

FOOTPLATE SCARIFICATION

The central portion of the footplate is first scarified to encourage postoperative fibrous union with the cut end of the posterior crus

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Central repositioning at the posterior crus is, to me, preferred to the use of the artificial crura, simply because I do not like foreign bodies in the ear Artificial crura may be indicated in extensive involvement of the crura where there is a reasonable area of normal or near-normal footplate I believe that artificial cruralization is to be preferred to solo footplate mobilization or simple a-crural footplate perforation (Rosen[15]) Artificial crura may also be indicated where there is marked otosclerotic narrowing of a deep oval window niche despite a relatively wide normal area of deep blue footplate This, to me, is the one specific indication for Schuknecht's[16] stainless steel cruralization I feel that both central repositioning of the crura and the use of artificial crura are limited to that 20 per cent of cases which show bi-crural otosclerosis, and possibly to some reoperations on the stapes in which the perfectly operable, ideal stapes has been violated by inadequate or inappropriate primary stapes surgery

FOOTPLATE EXCAVATION AND OVAL WINDOW GRAFTS

Up to this point we have been discussing surgery on those stapes which present a reasonable area of normal or near-normal stapedial footplate and bi-crural otosclerosis In these cases, I prefer the central repositioning of the posterior crus as a first choice, and as a second choice the use of the steel or polyethylene crura I do not fenestrate or excavate this oval window niche, as I like to have the central area of mobilized footplate protecting the inner ear I do not feel that making windows in the footplate is indicated when there is a reasonable area of normal or near-normal footplate

Excavation of the footplate and the application of an oval window graft may prove to be indicated in those cases where there is complete otosclerotic involvement of the footplate Shea[17] has had some dramatic success with the excavation of the footplate and the application of the vein graft I feel that this surgery has a role in the field of stapes surgery, however, I feel that it should be limited to those cases where there is complete otosclerotic involvement of the footplate

Complete otosclerotic involvement of the footplate usually manifests istelf clinically by a very wide air-bone gap, and is clinically the most suitable case for the fenestration operation Having had reasonable experience (Farrior[18,19,20,21]) with the modified Lempert[22] fenestration operation, I usually advise the fenestration, in clinically suitable cases, in the presence of complete footplate otosclerosis or in the presence of obliteration of the oval window niche, because the fenestration is the most predictable operation on the ear (Shambaugh[23])

HISTORICAL

My first case of crural repositioning, September 10, 1957, No 269, was performed on a class-D case, a 54-year-old judge with an 85 db hearing loss and a bone conduction loss of 42 db, a case on which I would not do a fenestration Examination of the stapes under the microscope revealed complete otosclerotic fixation of both crura In order to investigate the condition of the footplate, I fractured the crura free and moved them to one side This revealed a small central area of normal footplate This central area of footplate was mobilized, and the posterior crus repositioned over it I am not certain whether this trap-door in the footplate is fixed to the crus by a bony or a fibrous union, for the remaining posterior crus was very short, nevertheless, for the past 20 months, this patient has maintained a 43 db hearing improvement to the 42 db level There are a number of other cases of crural repositioning which have maintained excellent hearing improvement for more than one year In these cases, with the dissolution of the ossicular chain, the patient may obtain a significant hearing improvement in the operating room, but it is not the complete and dramatic improvement which occurs with an intact ossicular chain About four weeks must be allowed for union between the base of the posterior crus and the freely movable impacted central area of the footplate These patients may notice wide fluctuations in their hearing for the first month, but thereafter the hearing stabilizes

Analysis of results for the scientific exhibit presented at the A M A revealed that in bi-crural otosclerosis we had obtained only 18 per cent results From that time, May, 1958, crural repositioning was regularly employed with this standardized technique in the 19 cases of bi-crural otosclerosis which occurred in the 100 stapes mobilizations (371 to 470) in the period from May to December, 1958 These cases are selected for audio-analysis

PREOPERATIVE AUDIOGRAMS

I have long held the opinion that bi-crural otosclerosis is indicated clinically by a sloping audiogram (Farrior[14]) A review of these audiograms indicates that 84 per cent showed a gradual downward slope from the low to the high tones, with a greater than 10 db drop At this time I am undecided as to which is of the greatest clinical significance, the retained hearing for the low tones or the loss of hearing for the high tones, actually, I believe that the retained hearing for the low tones is indicative of a small area of normal or near-normal footplate, which is freely movable on the superior margin

Only one case (5 per cent) presented a rising audiogram A rising audiogram usually indicates a freely movable posterior half of the footplate, and it may be that in this particular case I may have made an error in diagnosis of the posterior crural involvement

Only one case (5 per cent) presented a flat audiogram A very flat audiogram with the wide air-bone gap of greater than 40 db is, to me, clinically indicative of complete footplate otosclerosis It may be that in this case the patient actually had complete footplate otosclerosis which was under-diagnosed In this case, No 374, the stapes mobilization was a failure, and we have subsequently done a fenestration operation In the course of the fenestration operation, No 756, the crura of the stapes were removed and the footplate studied under the microscope, revealing diffuse red vascular otosclerosis with complete marginal footplate fixation

IMMEDIATE RESULTS

The immediate results of this more complex stapes surgery is based upon the 30-day audiogram The statistical results reported are not intended to be final results The statistics are reported on the Otosclerosis Study Group form, as sug-

CHART No I

CRITERIA FOR REPORTING DEAFNESS IN THE SURGERY OF CONDUCTIVE DEAFNESS

1 Date of Report January 20, 1959
2 Period of Time during which surgery being reported was performed *May 20, 1958 to* Dec 10, 1958
3 Number of Cases operated during this period 100, 19 Bicrural otosclerosis
4 Number of Cases available from 3 with one month of later tests for this report 100 per cent

HEARING GAIN

Class	No Cases	Pathology	Operation	11 db or more No	11 db or more %	Hearing Level Over 30 No	Hearing Level Over 30 %	Hearing Level 30-40 No	Hearing Level 30-40 %	No Gain No	No Gain %	Losses No	Losses %
A	7	BIC	4+ CR	6	86	4	57	2	29	1	14		
B	7	BIC	4+ CR	6	86	5	71	1	14			1	-12
C	2	BIC	4+ CR	2	100			1	50				
D	3	BIC	4+ CR	2	66			1	33			1	33

PER CENT OF IMPROVEMENT

Class	No Cases	− % No	− % %	0-24% No	0-24% %	25-49% No	25-49% %	50-74% No	50-74% %	75-99% No	75-99% %	100%+ No	100%+ %
A	7			1	14	3	43	1	14	1	14	1	14
B	7	1	14					1	14	4	57	1	14
C	2							1	50	1	50		
D	3	1	33							2	66		

Chart No 1—The Audio-analysis of Cases of Crural Repositioning for BiCrural Otosclerosis is reported on a form suggested by the Otosclerosis Study Group, with addition of a column for the classification of the type of pathology and the type of Stapes Operation (BiC = BiCrural, CR = Crural Repositioning) The hearing gain is also subdivided gested by Dr Eugene Derlacki and his colleagues on this committee (Chart Nos 1-a, b) Because of our interest in the surgical pathology of the stapes, the relationship of the surgical pathology to the slope of the audiogram, and in computing the results of the various types of operations, I would advise including these categories immediately after the classifications into Groups A, B, C and D I would also add the 90-day, 180-day and 360-day findings, as suggested in the IBM form of Dr John Shea

CLASSIFICATION A, B, C, D

A review of the preoperative bone conduction audiogram shows that 37 per cent are in Category A, 37 per cent in Category B, 10 per cent in Category C, and 16 per cent in Category D

Of the A-cases, 86 per cent showed a gain of 11 db or more Of the 7 A-cases four, or 57 per cent, were at the 30 db level or better, an average hearing level of 24 db Two cases were between the 30 db and 40 db level, and had an average hearing of 33 db One case showed no gain in hearing and has had a successful fenestration No case showed a hearing loss The air-bone gap was closed 75 per cent or more in two cases, 50 to 74 per cent in one case, 25 to 49 per cent in three cases, less than 24 per cent in zero cases, and no gain in one case

Of the B-cases, 86 per cent showed a gain of 11 db or more Of the seven B-cases five, or 71 per cent, were at the 30 db level or better, an average hearing level of 19 db One case was between the 30 and 40 db level and had an average hearing of 33 db One case showed a hearing loss of 12 db The air-bone gap was closed 75 per cent or more in five cases, 50 to 74 per cent in one case, 25 to 49 per cent in none, less than 24 per cent in none, and no gain in one case

Of the C-cases, 100 per cent showed a gain of 11 db or more Of the two C-cases, none attained the 30 db level or better One case was between the 30 and 40 db level, and had a gain of 25 db to the 37 db level One case had hearing at the 48 db level but a gain of 30 db, and improvement in ability to lip read and use a hearing aid The air-bone gap was closed 75 per cent or more in one case and between 50 and 74 per cent in the other

Of the D-cases, 66 per cent showed a gain of 11 db Of the three D-cases, none attained the 30 db level or better One D-case attained an average hearing level of 35 db, with a gain of 37 db One recent patient experienced a 41 db gain to the 43 db level, but this has regressed to a 20 db gain, either from re-fixation or loss of ossicular continuity One case showed a hearing loss of 10 db The air-bone gap was closed 75 per cent or more in the other two cases

LABYRINTHINE DISTURBANCE

With this much stapes surgery, I was concerned about persistent postoperative vertigo In response to the questionnaires, two patients stated that they have slight dizziness

LONG TERM RESULTS

The long term audiograms are not yet available on these cases performed in mid-1958 after crural repositioning became a standardized procedure for bi-crural otosclerosis We do have isolated audiograms on individual cases showing phenominal hearing gains and hearing levels *retained for more* than one year, with the longest case 20 months postoperative

It is my hope that long-term audiograms will be available before publication Current response to the questionnaire indicates that of those who experienced hearing improvement, four patients have lost their hearing gain, leaving well over 50 per cent who have retained their hearing improvement and classify their hearing as good or very good

SUMMARY

1 Otosclerotic involvement of both stapedial crura is pathologically beyond the limits of reasonably predictable total stapes mobilization surgery

2 Bi-crural otosclerosis is a positive indication for specialized surgical techniques

3 When there is bi-crural otosclerosis and a reasonable area of normal or near-normal stapedial footplate, I advocate central mobilization of the uninvolved footplate and central repositioning of the posterior crus as a possible method of maintaining hearing improvement

4 Central repositioning of the posterior crus is accompanied by tendonotomy, anterior crurotomy, and central footplate mobilization The technique of central repositioning is described

5 Artificial cruralization is indicated in bi-crural otosclerosis when the crura are extensively involved and there is a

CHART NO II—STAPES OPERABILITY

	SURGICAL PATHOLOGY	APPROPRIATE OPERATION
1	Anterior Footplate Otosclerosis, Superficial footplate	Direct mobilization, pick inserted anteriorly
2	Anterior Footplate, Deep Footplate	Indirect mobilization at incus
3	Anterior Crural Otosclerosis	Anterior crurotomy, mobilization posterior footplate and crus
4	Anterior Crural, Superior or Inferior Marginal Otosclerosis	Anterior crurotomy, mobilization posterior footplate and crus
5	Bi Crural Otosclerosis, Some normal footplate, wide niche	*a* Anterior crurotomy and mobilization central footplate and crural repositioning
	Same, narrow niche	*b* Mobilization central footplate and artificial cruralization
6	Complete Footplate Otosclerosis Thin (Annulus visible, Superficial Footplate)	Circumferential footplate mobilization
7	Complete Footplate Otosclerosis, Thick (Annulus not visible)	Oval window graft, Lempert fenestration
8	Obliteration of oval window niche	Lempert fenestration usually required, but if there is a small area of deep, normal blue footplate decrural footplate mobilization or artificial cruralization may be attempted
9	Revisions of the stapes mobilization is indicated only if the primary pathology was favorable and the primary surgery inadequate, or inappropriate for the specific pathology	
10	Revisions of the stapes mobilization are not indicated in the presence of primarily unfavorable anatomy and pathology, these are indications for the fenestration operation	

Chart No 2—Surgical judgment is required to evaluate the surgical pathology of the stapes in order to apply the appropriate surgical technique reasonable area of normal or near-normal footplate, or when there is marked narrowing of the deep, oval window niche, artificial crura need not be employed indiscriminately.

6 Footplate windows and oval window grafts may be indicated in complete footplate otosclerosis in cases not suitable for the fenestration operation

7 In complete footplate otosclerosis, with an adequate air bone gap, the modified Lempert fenestration operation is my procedure of choice

8 At the present time, most all stapes surgeons are developing their own techniques for overcoming the more complex varieties of stapes pathology. It is my sincere hope that this posterior crural repositioning will be of lasting benefit in some cases of bi-crural otosclerosis

9 With the operating microscope and modern surgical instruments, it is possible to do almost anything to the stapes Surgical judgment is required to do the right thing My current opinion as to pathological indications for the various types of stapes operations in indicated on Chart 2, showing the basic classification of stapes pathology, and the corresponding indicated basic types of stapes operations

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509 Bay Street

ULTRASONIC THERAPY FOR RELIEF OF VERTIGO DUE TO MENIERE'S DISEASE[*][†]

WM M S IRONSIDE, M D (By Invitation),
and
J R LINDSAY, M D,

Chicago, Ill

Since Langevin in 1916 started studying the effects of ultrasound there has been a steadily increasing interest, so that today to glance through the literature is to be astounded at the volume of publications

If we confine our attention to those reports of interest to the otologist we find that some few used ultrasound in the treatment of otosclerosis in the years 1928-1933 [1] Due to the equivocal results achieved nothing more appeared until 1949[2], however, since then there has been increased interest, and the work of Krejci[3] stimulated others to apply ultrasound to the vestibule in experimental animals and directly to the horizontal canal in the treatment of Meniere's disease[3,4] Today there are a number of reports on the clinical use of the beam in this condition

Undoubtedly the experience of Arslan[5] is the most extensive but reports of Portmann, et al,[6] Dubs[7] and Lumsden[8] are worthy of study

METHODS OF PRODUCING ULTRASOUND

Ultrasound is sound which has a frequency above 18 kilocycles or above that which can be detected by the human ear There are three ways in which ultrasound can be produced *mechanical, magneto striction,* and through *piezoelectric* effect This last is the method used clinically as only with it can radiation of sufficient frequency and intensity be obtained

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[*] Read at the meeting of the Middle Section of the American Laryngological Rhinological and Otological Society Inc St. Louis Mo Jan 12 1959

[†] From the Section of Otolaryngology of The University of Chicago

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When electrical charges are applied to the surfaces of a crystal, vibrations of the crystal result One of the most suitable crystals is quartz and is most frequently used

PHYSICS

Generally, ultrasound behaves in the same fashion as audible sound, but there are one or two differences which are of clinical importance Vibrations travel four times faster in liquids and 20 times faster in solids than in air

Though sound is transmitted with ease and uniformity through homogeneous media, at the interfaces of two dissimilar conductors, such as quartz and air, or even water and air a large portion of energy is reflected, furthermore, at such interfaces there develop waves traveling at right angles to the axis of the beam

METHODS OF APPLICATION TO EAR

1 *External mastoid* Here the beam is applied to the skin overlying the mastoid process

2 *Transmeatal* This is the method as described by Portmann and Barbe[9]

3 *Direct application to the bony horizontal canal* This is the method as used by Krejci, Arslan, Lumsden and Dubs

From the preceding section on the physics of ultrasound it would appear that the last method, with direct application to the horizontal canal would be most likely to produce an effect localized to the vestibular receptors When using the first and second methods for treatment of the vestibular receptors there would be considerable loss of energy at the interfaces, and the beam could not be directed accurately

EQUIPMENT USED

The machine used is that developed by an Italian company for Professor Arslan It consists essentially of a high frequency generator connected to the erogating head which is water cooled (see Figs 1, 2, 3, 4)

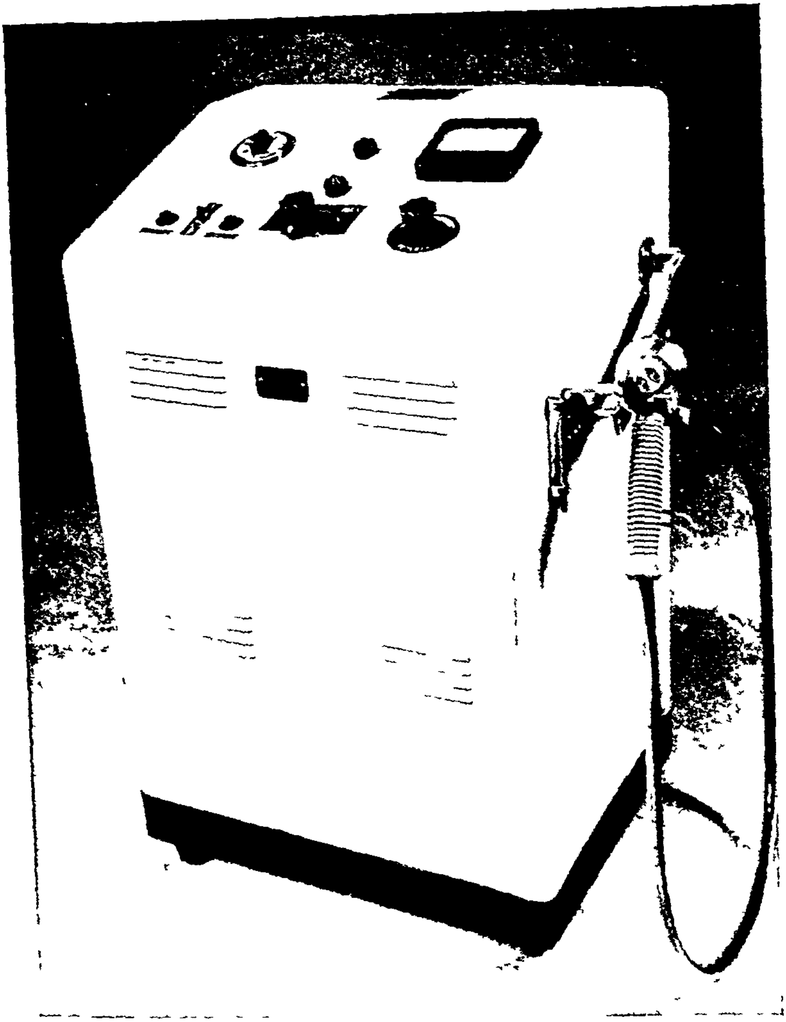
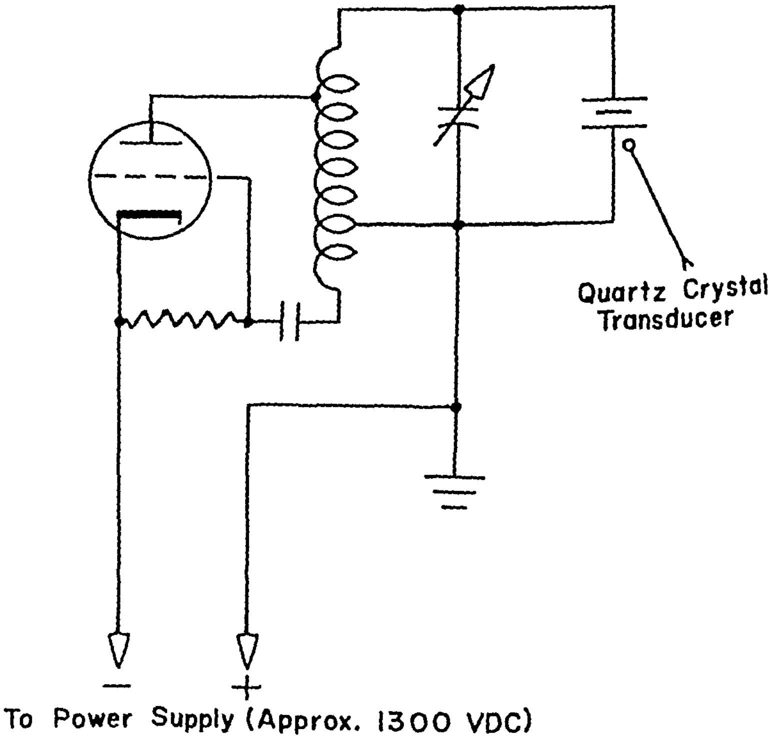


Fig 1 Photograph of the Ultrasonic Apparatus

The area of the circular flat tip of the erogating head is 0 2 sq cm, and the frequency is approximately 950 kilocycles per second as tested by the ultrasonic probe The intensity dial on the machine is supposed to give the intensity of the delivered beam and not the intensity output of the electrical circuit, furthermore, there is a frequency control dial, but this is only effective over a limited band of approximately 40 cps and is used as a fine control to set the beam at the start of the procedure, and during the operation also to offset changes in the frequency resulting from changes in temperature, amount of fluid or blood at the tip and also changes in the position of contact between tip and bone of horizontal canal



SIMPLIFIED SCHEMATIC DIAGRAM OF ULTRASOUND GENERATOR

Fig 2

BIOLOGICAL EFFECT OF ULTRASOUND

It is known that ultrasound has three effects *1* Thermal, *2* mechanical, *3* chemical That they are of varying importance in different fields is known, but their relative importance in the ear has not yet been shown by experimental work so far undertaken That heat to a considerable degree

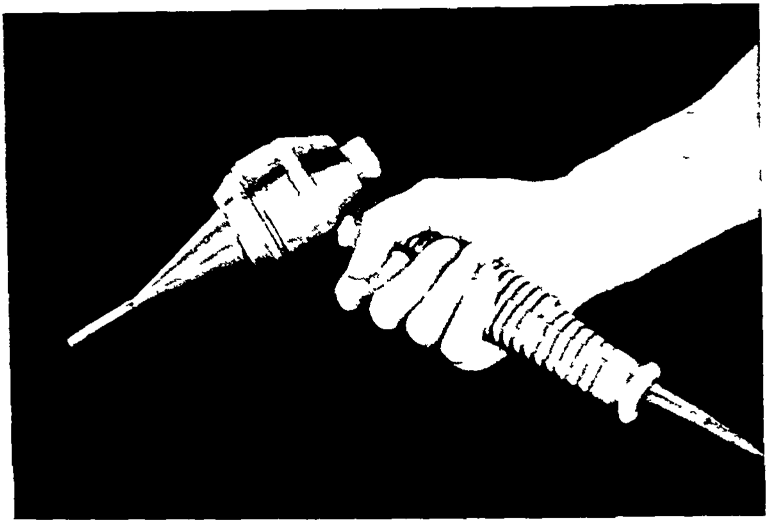


Fig 3 Photograph of the Erogating Head

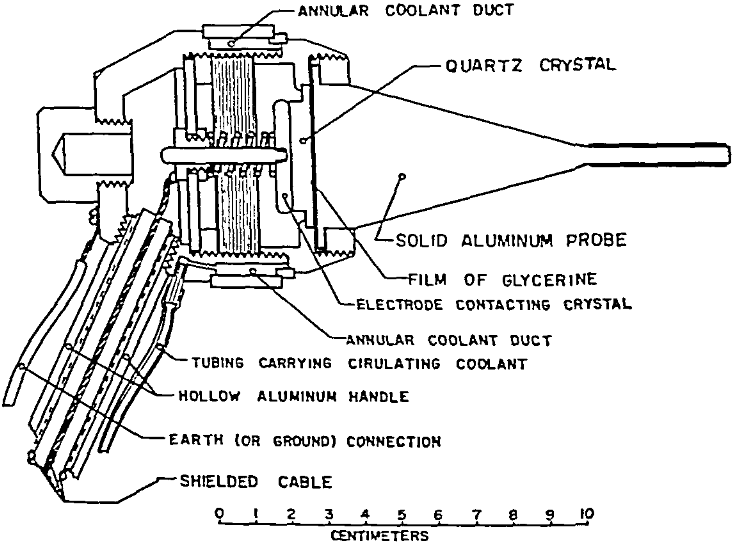


Fig 4

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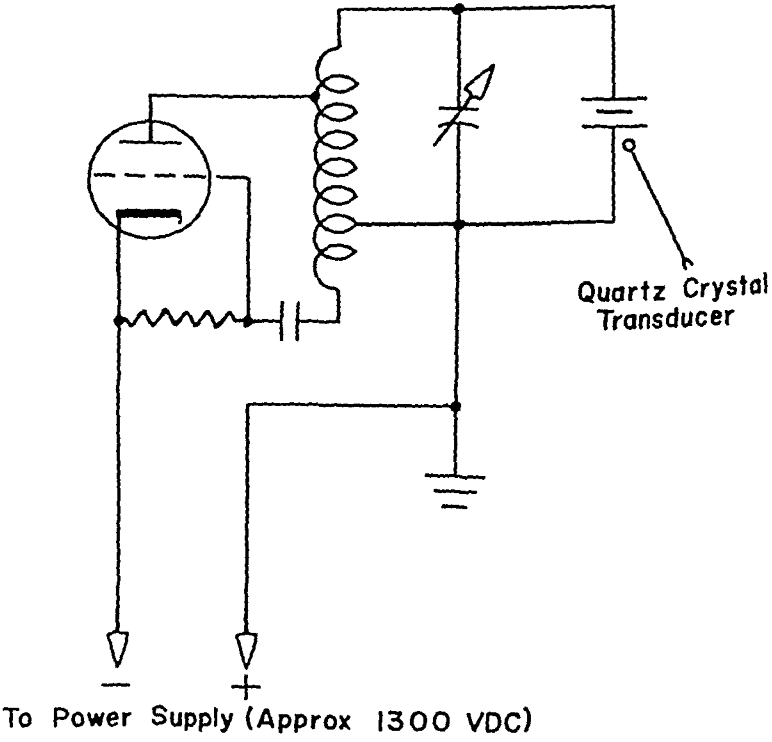

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BIOLOGICAL EFFECT OF ULTRASOUND

It is known that ultrasound has three effects *1* Thermal; *2* mechanical, *3* chemical That they are of varying importance in different fields is known, but their relative importance in the ear has not yet been shown by experimental work so far undertaken That heat to a considerable degree fortunately the observation of induced nystagmus gives a reliable guide as to dosage required Due to failures in the apparatus the duration of application and the intensities used have varied considerably The duration varied from 70 minutes to 15 minutes The intensity has also varied considerably from starting at 6 watts per sq cm up to 12 watts per sq cm With the recent acquisition of an ultrasound probe we are now in a position to determine more accurately the frequency and intensity of the beam and detect early any defect in the machine

In the last three cases the starting intensity has been 8 watts per sq cm After one to two minutes "irritative" nystagmus or nystagmus to the same side appears This is usually brisk and is sustained At this point the intensity is increased to 9 or 10 watts per sq cm. This irritative nystagmus continues for a varying period when "paralytic" nystagmus, or nystagmus to the opposite side, ensues There may be an abrupt change from one type to the other, or there may be a period of a few minutes when there are brief episodes of the paralytic form reverting to irritative until finally the paralytic nystagmus becomes constant, or there may be a few minutes between the cessation of irritative nystagmus and the onset of paralytic nystagmus when there is no definite movement of the eyes to one or other side

Occasionally a rotatory component is noted and this results, we suspect, from the beam affecting the posterior end of the posterior vertical canal As indicated, contact between erogating tip and bony horizontal canal is made towards the posterior part of the canal This has been done from the outset as it was Arslan's experience that facial paralysis, even though of only a temporary nature, can ensue if the beam is directed too far anteriorly One should also avoid directing the beam towards the cochlea or disturbing the incus It is known also that the desired clinical effect on the neuroepithelium placed anteriorly can be obtained even when erogating posteriorly[12]

The erogating head is removed when the paralytic nystagmus has been constant for one to four minutes At those times when the machine was obviously not functioning properly and periods of up to 66 minutes were required to induce is produced by ultrasound applied to the ear has been shown, but whether this is the main effect has not been proved. Histological changes produced by ultrasound have been studied by Krejci and Bornschein,[3] Portmann, Portmann and Barbe,[9] Naumann[10] and de Stefani.[11] Degrees of effect from hyperemia to tissue necrosis have been observed, and this depends on the dosage and technique used. Of great interest is the work of de Stefani which shows the destruction of the neuroepithelium with preservation of the cupula.

TECHNIQUE

The method used is similar to that described by Professor Arslan.

The average patient receives sodium pentobarbital 180 mg two hours and Meperidine hydrochloride 100 mgm. 30 minutes before operation as premedication. Local anesthesia is then induced and a cortical mastoidectomy performed. It is essential to gain a good exposure of the horizontal canal to permit correct positioning of the erogating head. Four of the operations have been performed through the postaural route (WMSI) and two by the endaural (JRL) and there seems to be no justification for the claim that the postaural route is preferable to gain the necessary exposure.

Gaining through the experience of Arslan, we apply the tip towards the posterior end rather than on the convexity of the horizontal canal. In this manner we have escaped the unfortunate early experience of Arslan and Lumsden with facial palsies. Prior to applying the erogating tip the posterior part is brought into prominence and the surface flattened by careful removal of bone. This is done to insure good contact, the importance of which has already been indicated. Thorough hemostasis is then secured, and a fine suction tip placed in the posterior part of the cavity.

During the period of erogation a second assistant is required to operate the machine and watch the eyes for nystagmus and the face to detect any twitching indicative of facial nerve stimulation.

The dosage applied varies from patient to patient, but

VERTIGO

Four have gained complete freedom from vertiginous attacks and two have improved One of the latter unfortunately is showing signs and symptoms of involvement of the other side Arslan reports success in 94 per cent of 195 cases and Lumsden 19 (four with modified attacks) out of 22 [9]

Following the caloric responses pre- and postoperatively has been of considerable interest Two patients were subjected preoperatively to the modified Kobrak test and showed diminished response on the affected side Four were tested by the differential caloric test and the results were, two canal pareses, one preponderance to the opposite side and one combined lesion of the same side

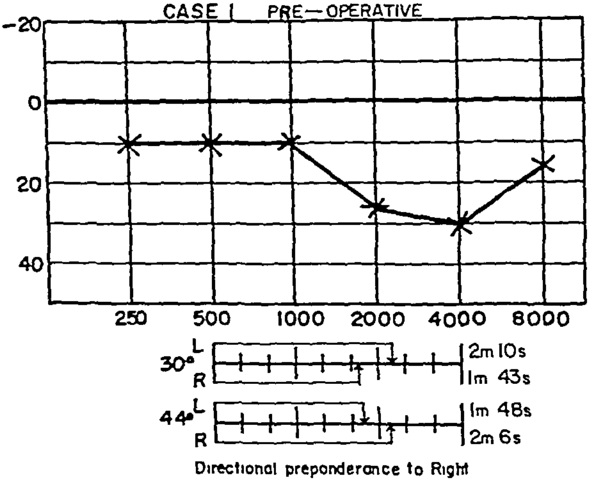

Fig 5 Case 1 illustrates one preoperative audiogram in the affected ear also the caloric responses on that occasion The audiogram on this date was not characteristic of Meniere's disease

Immediately following removal of the eroding tip from the cavity in two patients, warm water at approximately 45° C was run into the cavity In both cases this induced an inhibition of the paralytic nystagmus to the opposite side, whereas when the sucker was applied just over the horizontal canal causing cooling, the paralytic nystagmus was enhanced By paralytic nystagmus, the tip was left in position for an additional four minutes When the paralytic nystagmus appeared in 14 minutes then only one minute of further treatment was given Gelfoam soaked in penicillin was then placed in the cavity and the incision closed completely without drainage

Even the extremely nervous patient has withstood the procedure well in spite of the intense vertigo experienced In only one case has vomiting occurred

POSTOPERATIVELY

The vestibular disturbance induced by the procedure is quite marked and spontaneous nystagmus of paralytic nature,

TABLE I

Results Obtained by Ultrasonic Therapy

Number	Application of US	Vertigo	Tinnitus	Hearing
1	65 minutes	Improved	Never present	No change
2	70 minutes	Free	Reduced	Improved
3	30 minutes	Improved	Unchanged	Worse
4	31 minutes	Free	Reduced	Improved
5	60 minutes	Free	Reduced	Worse
6	15 minutes	Free	Reduced	Improved

that is to say to the opposite side, has been noted up to the sixth day, however, usually within 48 hours this spontaneous nystagmus has cleared, and the patient can be up but is still experiencing vertigo on any movement of the head The patient is usually fit to return home at the end of eight days Generally it has taken the successfully erogated patients up to two and a half or three months to be free of the results of the operation—one would expect such a period of time to elapse before compensation developed

RESULTS

It is well to state at this stage that the six patients subjected to this procedure had been exposed to the usual conservative therapeutic measures for periods from 17 months to three years prior to operation, and none of them had gained any appreciable benefit The youngest was 31 years and the oldest 57 years

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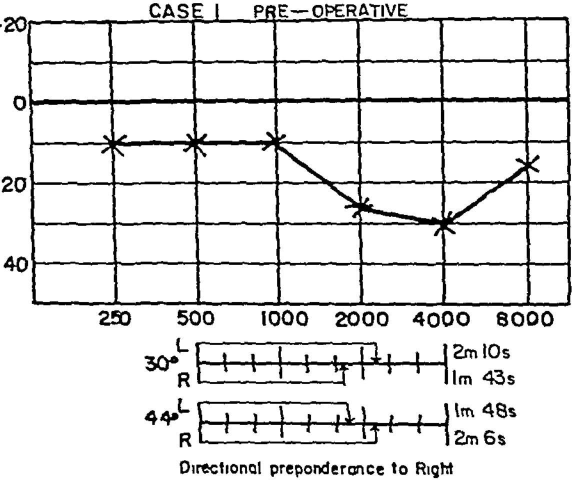

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RESULTS

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Within two and a half months of the operation she had renewed her social activities and again enjoyed her children She stated recently (three weeks ago) that though she occasionally feels unsteady she has had no true vertiginous attacks as experienced prior to the operation

In two patients during the period after the loss of response to water at 18° and while 4° C water still stimulates, we have observed induced nystagmus to the same side, the reverse of what one would expect

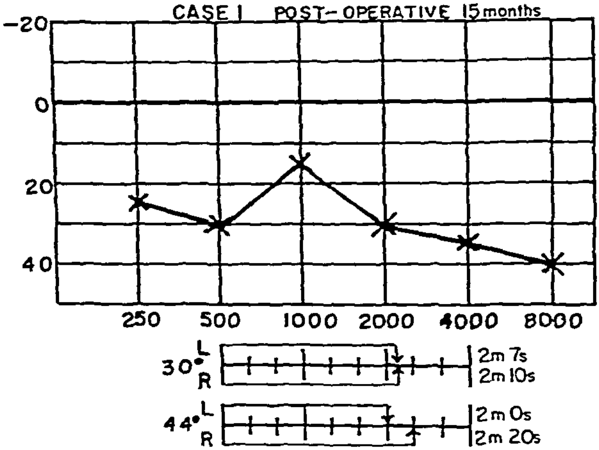


Fig 7 Case 1 AC threshold is again elevated Caloric responses are within normal limits at 15 months

Although the patient can get about without too much difficulty within ten days after operation, quick head movements may cause discomfort up to two or three months; also positional nystagmus has been observed up to two months This we take to indicate that the ultrasound induces only a partial destruction of the vestibular system[13]

TINNITUS

Five of the six patients experienced tinnitus prior to operation Of these five, one has sensed no change, while in four the intensity has been reduced, and where intermittent, the frequency reduced, following the operation the end of two weeks, when the ear has healed, there is generally no response to water at 18° C though it may take up to three months or longer for disappearance of the response to 10 cc water at 4° C

This amply confirms what has been shown in animal experiments that the lesion caused by ultrasound is not complete immediately but is progressive over a period of weeks or even months, further, the lesion may be of a temporary nature[2] This is shown in Case 1 Preoperatively (see Fig 5) the differential caloric had a pattern of directional preponderance to the opposite side Four months postoperatively (see Fig 6) there was no response to 30° C water during the differential caloric, and 10 cc of 4° C water failed to elicit a response, however, 15 months postoperatively (see Fig 7) the differential caloric responses are within normal limits The patient has had, however, definite benefit from the operation For 17 months prior to operation this patient had been under conservative therapy without benefit For two months prior to operation she had been confined to the house, had to have help to care for her children and had withdrawn socially

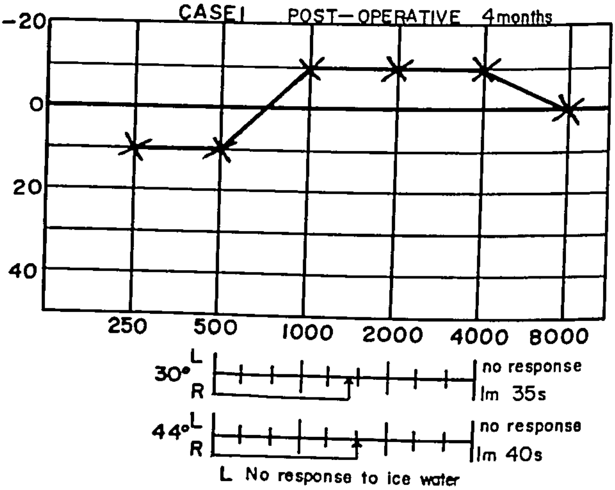


Fig 6 Case 1 AC audiogram four months after ultrasonic treatment Note absence of caloric response in left ear and lowering of the AC threshold

the threshold as an indication of the continuation of the disease process albeit without vertiginous attacks, and there are symptoms and signs to suggest this, then it would be surprising to achieve a true and permanent lowering of the threshold

COMPLICATIONS

In two cases the middle ear contained blood for approximately two weeks after the operation, but this cleared spontaneously

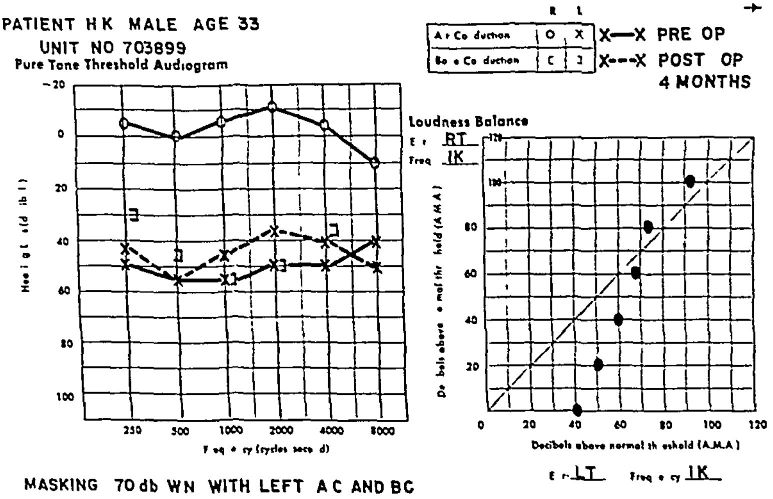


Fig 9 Case 6 Menieres disease left ear Note slight apparent improvement in hearing four months after operation Such shifts in the threshold are characteristic of Menieres disease and may not indicate improvement due to the treatment

In one a wound abscess developed necessitating re-hospitalization and antibiotic therapy

No facial paralysis even of a temporary nature was encountered

CONCLUSION

Although the dosage used in this series of cases has been

HEARING

Arslan[5] has reported 40 to 50 per cent of cases of Meniere's disease gaining an improvement in hearing following the application of ultrasound, but Lumsden found that only one out of 22 cases showed improvement Our cases have not been followed for a long enough period to assess the effect of ultrasound That complete loss of hearing has not resulted is at least certain The most recent audiograms indicate that some improvement has occurred in three cases (see Figs 8, 9), one remains unchanged and two have lost some hearing since the operation

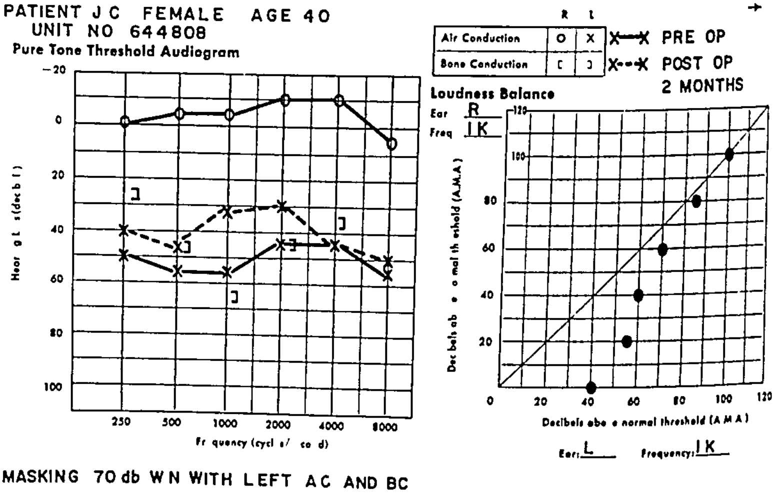
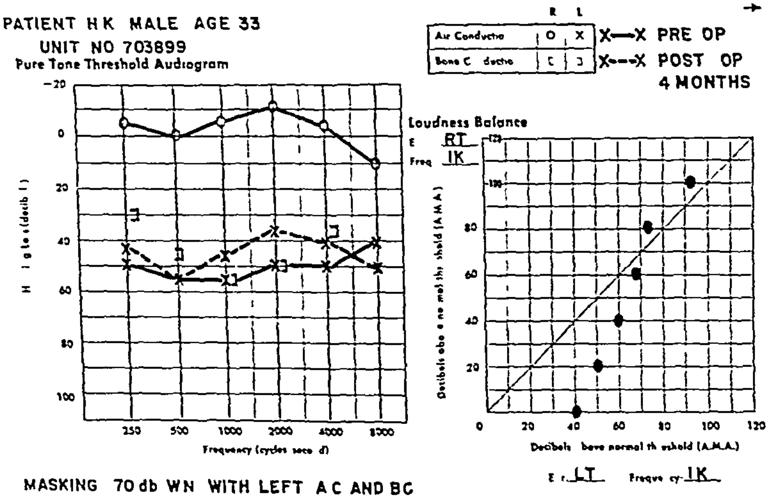


Fig 8 Case 4 Typical audiogram and loudness balance test for Meniere's disease left ear Note apparent improvement in hearing two months after treatment

As seen in Case 1 there are considerable changes in the threshold during the postoperative period (see Figs 6, 7), as well as in the preoperative period, so that unless one is in the position to compare a series of preoperative audiograms taken during and between attacks with a series of audiograms over many months or even a year in the postoperative period, it is impossible to assess accurately the effect of ultrasound on the hearing, furthermore, if one takes the variations in the threshold as an indication of the continuation of the disease process albeit without vertiginous attacks, and there are symptoms and signs to suggest this, then it would be surprising to achieve a true and permanent lowering of the threshold

COMPLICATIONS

In two cases the middle ear contained blood for approximately two weeks after the operation, but this cleared spontaneously



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In one a wound abscess developed necessitating re-hospitalization and antibiotic therapy

No facial paralysis even of a temporary nature was encountered

CONCLUSION

Although the dosage used in this series of cases has been variable and in some inadvertently conservative, the results obtained in the control of attacks of vertigo have been consistently favorable

Hearing has been retained in all cases

There has been no case of facial palsy Recent reports by Arslan and Lumsden in larger series of cases also give reassurance that permanent facial nerve injury may be avoided providing that adequate care is used during treatment

In view of the experience with this small group of cases, supported by the experiences of others, we feel justified in using ultrasonic therapy in preference to other methods of labyrinthine destruction

Certain findings in the postoperative audiograms and caloric responses are presented without explanation They indicate a need for further study of the peripheral vestibular system Also the effect of ultrasound on the receptor organs requires more precise investigation

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EVALUATION OF LARYNGECTOMY WITH RADICAL NECK DISSECTION*

JOHN J O'KEEFE, M D ,

Philadelphia, Pa

Carcinoma of the larynx of extra-cordal origin, or of cordal origin but with gross extension to structures adjacent to the cord, are more malignant lesions than are those cancers confined to the true vocal cords This is attested to in the high incidence of metastases associated with them Not only are such lesions frequently of a higher anaplastic histologic classification, but anatomically they possess the potential of metastasizing relatively easily. Additionally, the lesions of extra-cordal origin are usually asymptomatic in their early growth, thereby allowing for lymphatic invasion before arousing subjective complaints

The detectable presence of cervical lymph nodes, in proven instances of laryngeal cancer, is presumptive evidence of regional metastases When such nodes are ascertained preoperatively, there is no question that they constitute a positive indication for radical neck dissection as a component part of the primary operative procedure, regardless of the location, extent, or stage of development of the laryngeal growth, however, in instances of similarly classified laryngeal lesions, but which are further characterized by impalpable cervical lymph nodes, a real and serious controversy exists disputing the necessity for such extensive or additional surgery

In appraising this issue, it is of critical importance to bear in mind that inability to palpate cervical lymph nodes preoperatively does not constitute the criterion by which one adjudges the rationale of combining neck dissection with laryngectomy for the resection of such laryngeal lesions, rather, it is because of the known behavior pattern of these cancers, that their location, either by origin or by extent, is incriminated as the principal characteristic by which their ability to metastasize is determined This, therefore, is the criterion which would influence and direct such judgment It is equally important to realize that cervical metastases, either gross or microscopic, exert a grave influence on mortality The greater seriousness of this problem lies in the fact that the disease has now extended beyond the confines of the larynx, and threatens general body dissemination At best, prognosis is guarded, for, as with the evaluation of cancer generally, prognosis is considered favorable only when the primary lesion is small, when it is situated wherein lymphatic drainage is scant, and when regional metastases cannot be demonstrated

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*Read at the Sixty-Second Annual Meeting of the American Laryngological Rhinological and Otological Society Hot Springs Va March 8-10, 1959

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CLASSIFICATION OF MATERIAL

Even under optimum circumstances, an accurate classification of a laryngeal tumor is often a difficult task This is especially true in the present study, wherein the tumors under consideration are essentially far advanced and extensive ones, with many of their characteristics distorted or hidden Tumors whose site of origin cannot be discerned, are classified according to the structure involved by the greatest amount of growth, even though more than one anatomic part may be involved Palpable cervical lymph nodes are considered metastatic lesions, and are evaluated preoperatively only as resectable or not

Laryngectomy with unilateral neck dissection, as a one-stage procedure, was performed in 153 cases This operative method is referred to as prophylactic or protective when neck nodes are impalpable, and as definitive when neck nodes are palpable, accordingly 85 of these operations were definitive procedures, and 68 were prophylactic Laryngectomy alone, since 1950, was performed in only 107 cases Failures relative to this operative method, manifested as metastases to the regional lymph nodes, were operated by secondary radical neck dissection The results obtained by these various operative procedures will be evaluated and correlated with the criteria by which they were selected as the operation of choice

I DEFINITIVE LARYNGECTOMY WITH RADICAL NECK DISSECTION

Palpable cervical lymph nodes, associated with a proven carcinoma of the larynx, constitute a positive indication for resection by laryngectomy with neck dissection In arriving at this decision, one should not be influenced by the size or location of the laryngeal lesion, nor by the size or number of palpable cervical nodes Any other method, or any method of less extent, is contrary to the accepted principles of cancer surgery

The following statistics are practical applications of this argument In the series of 85 definitive operations, the laryngeal tumor in 37 instances was located supraglottically, in 31 instances it was cordal, but with gross extension either anteriorly or posteriorly, and in 17 instances its principal location was subglottic In the supraglottic group, the associated cervical lymph nodes contained cancer in 24 cases, 64 8 per cent, in the extensive cordal group, lymph nodes were positive for cancer in 18 cases, 58 per cent, and in the subglottic group, these nodes were positive in 10 cases, 58 8 per cent

TABLE I

Laryngectomy with Radical Neck Dissection—Cervical Nodes Palpable

Location	Number of Cases	Nodes Positive for Cancer	Per Cent
Supraglottic	37	24	64 8
Cordal	31	18	58 0
Subglottic	17	10	58 8

The proximate similarity of these percentage rates, reflecting the incident presence of cancer in the palpable cervical lymph nodes in these three groups of patients, factually supports the premises that laryngeal cancer, either originating or extending beyond the confines of the true vocal cord, is readily capable of metastasizing, and that associated palpable cervical lymph nodes should be presumed to represent malignant metastases Conclusive evidence of the malignant potential of these lesions is revealed in the fact that in spite of such extensive surgery, 20 of these patients are dead of cancer, 23.5 per cent.

II. PROPHYLACTIC LARYNGECTOMY WITH RADICAL NECK DISSECTION

Laryngeal carcinomas, as described and classified previously, but which are further characterized by impalpable cervical lymph nodes, are said to constitute a relative indication for resection by laryngectomy with radical neck dissection. "Relative" is interpreted to mean that the operator has a choice in his selection of operation, which choice assumedly derives from the absence of palpable cervical lymph nodes. This is an unwarranted and unfounded reason for proposing a choice of operation. Having established the significance of location, as the principal if not the only characteristic which determines the ability of these laryngeal tumors to metastasize, this characteristic should be the sole determining factor in evaluating the need for adding neck dissection to laryngectomy for their resection. The inability to palpate regional lymph nodes is irrelevant to the issue.

TABLE II

Laryngectomy with Radical Neck Dissection—Cervical Nodes *Impalpable*

Location	Number of Cases	Nodes Positive for Cancer	Per Cent
Supraglottic	28	9	32.1
Cordal	18	2	11.1
Subglottic	22	5	22.7

The second part of this study is presented in support of this assertion. Sixty-eight prophylactic combined operations were performed on patients classified as noted above, and who in common were adjudged to have no evidence of regional metastases preoperatively. The laryngeal tumor was located supraglottically in 28 instances, grossly cordal in 18 instances, and in 22 instances its principal mass was subglottic. The lymph nodes contained in the resected cervical tissues were histologically positive for cancer in 16 cases, 23.5 per cent; specifically in nine of the supraglottic group, in two of the cordal cases, and in five of the subglottic group.

These 16 cases surely would have developed overt metastic lesions had the primary surgery been limited to laryngectomy alone Undetected or undetectable metastic cancer occurring in approximately 25 per cent of patients is reason enough to consider this type of laryngeal lesion an absolute indication for resection by laryngectomy with radical neck dissection Again, it is stressed that inability to palpate cervical lymph nodes is not relevant to this issue Of utmost importance is the fact that 12 of these 16 patients are alive and apparently free of cancer for more than three years postoperatively The four deaths, 5 8 per cent, are all attributable to metastic disease

III PRIMARY LARYNGECTOMY

Between 1950 and 1955, only 107 cases of cordal cancer were operated by total laryngectomy This relatively small number is a consequence of the increasing number of combined operations being performed as primary surgical procedures The laryngeal lesions, although classified cordal in location, evidenced gross extension anteriorly or posteriorly, or both, so that commonly there was involvement of the anterior commissure or of the opposite cord, and/or fixation of the arytenoid Essentially, they constitute extensive cordal cancers, without demonstrable signs of palpable cervical nodes

TABLE III

PRIMARY TOTAL LARYNGECTOMY

Number of Patients Operated	107
Number of Failures	31
Per Cent of Failures	28 9

Laryngectomy failures, noted as malignant metastases to regional lymph nodes, occurred in 31 instances, 28 9 per cent Twenty-five of these were operated by secondary radical neck dissection, and two were irradiated One of the irradiated patients is alive and free of disease more than five years after therapy, the other is dead of cancer Sixteen of the 25 operated patients are alive and well, three or more years postoperatively, a proximate salvage rate of 64 per cent, but a total salvage rate of only 51 6 per cent Ten of the 31 primary failures are dead of cancer, 32 2 per cent

This group of patients, representative of extensive cordal cancer without regional metastasis, presumably had been properly selected for primary laryngectomy, yet the initial failure rate of almost 30 per cent contradicts the assumption that cordal cancers are not prone to metastasize, and at the same time, signifies the inadequacy of this operative method

DISCUSSION

Cancers of the larynx classified as extra-cordal, whether by origin or by extent, are potentially highly malignant Their degree of malignancy derives from their location rather than from any other characteristic, and is objectively assessed through the identification of regional metastases

The successful surgical treatment of these forms of laryngeal cancer is inherently dependent upon an acceptance of this appraisal This is borne out in the present study where, in employing total laryngectomy with radical neck dissection as the only operative procedure, the failure rate incident to the resection of laryngeal lesions associated with palpable cervical lymph nodes preoperatively, was four times greater than that resulting from operating the same type of laryngeal lesions, but which were free of demonstrable preoperative cervical metastases The resected cervical nodes, in 85 patients operated by definitive laryngectomy with neck dissection, were positive for cancer in approximately 60 per cent of cases, the nodes contained in the tissues resected through operating 68 patients by prophylactic laryngectomy with neck dissection, were positive for cancer in 23 5 per cent This, in summary, is the crux of the problem Cervical metastases occur easily and relatively early in laryngeal lesions of extra-cordal location, that for the successful resection of these cancers, one should anticipate the development of such metastases and make adequate provision for their resection, and that "prophylactic" is actually a superfluous term in describing the appropriate method of resection

Additionally and somewhat parenthetically, the malignant

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DISCUSSION

Cancers of the larynx classified as extra-cordal, whether by origin or by extent, are potentially highly malignant Their degree of malignancy derives from their location rather than from any other characteristic, and is objectively assessed through the identification of regional metastases

The successful surgical treatment of these forms of laryngeal cancer is inherently dependent upon an acceptance of this appraisal This is borne out in the present study where, in employing total laryngectomy with radical neck dissection as the only operative procedure, the failure rate incident to the resection of laryngeal lesions associated with palpable cervical lymph nodes preoperatively, was four times greater than that resulting from operating the same type of laryngeal lesions, but which were free of demonstrable preoperative cervical metastases The resected cervical nodes, in 85 patients operated by definitive laryngectomy with neck dissection, were positive for cancer in approximately 60 per cent of cases, the nodes contained in the tissues resected through operating 68 patients by prophylactic laryngectomy with neck dissection, were positive for cancer in 23 5 per cent This, in summary, is the crux of the problem Cervical metastases occur easily and relatively early in laryngeal lesions of extra-cordal location, that for the successful resection of these cancers, one should anticipate the development of such metastases and make adequate provision for their resection; and that "prophylactic" is actually a superfluous term in describing the appropriate method of resection

Additionally and somewhat parenthetically, the malignant potential of diffuse cordal cancers is little less than that of cancers of extra-cordal location The 29 per cent laryngectomy failure rate of this carefully classified group of patients, further supports the rationale of recommending more extensive surgical measures as primary resection techniques, even for lesions of this limited extent In so doing, the basic tenet of cancer surgery, that of saving life, will be better served

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TEMPLE UNIVERSITY SCHOOL OF MEDICINE AND HOSPITAL

Postgraduate Course in Laryngology and Laryngeal Surgery, September 21st to October 2nd, 1959

Postgraduate Course in bronchoesophagology, November 9th to 20, 1959

These courses are to be given in the Department of Laryngology and Bronchoesophagology, Temple University Medical Center, under the direction of Drs Chevalier L Jackson and Charles M Norris

The tuition fee for each course is $250 Application and further information can be obtained by writing to Jackson-Research, Lab 604, Temple University Medical School, 3400 N Broad Street, Philadelphia 40, Pa

TRIGEMINAL NEURALGIA—TIC DOULOUREUX*

JAMES P RIGG, M D ,
and
ROBERT W RIGG, M D ,
(By Invitation),

Grand Junction, Colo

Recently Dr Stanley P Reimann, of Philadelphia, stated "Tomorrow is being born today in medical research laboratories We have no crystal ball, and it may be folly to prophesy what will be discovered, but much progress is evidenced everywhere As ever, more accurate instruments are being given to us by our friends in mathematics, physics, engineering, and in many other fields, thereby presenting many new facets of investigation

"The ideal of the doctor is that no one should die of disease, but should live his allotted life span and then quickly fall apart like the famous one-horse shay We are far from this ideal, but it is a goal we are all striving for"

Pain is an ever-present problem in medicine, and we, as doctors, are striving constantly to alleviate this It is our hope and our desire that pain of any type can be adequately controlled, and permanently dissipated Concurring with Dr Walter Scott that "man can look forward with eager anticipation to continuing progress in the medical sciences, but the unfolding of each new step will likely be evolutionary, rather than revolutionary Research is currently knocking at the door which will soon open and lead to worldwide control of viral diseases"

Dr Scott further states "Degenerative processes, particularly arteriosclerosis, together with the ever-increasing turmoil in man's emotional life, will be conquered more slowly and along lines not presently known, however, I do not expect

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*Read at the Meeting of the Western Section of the American Laryngological Rhinological and Otological Society Jan 17 1959

Editor s Note This manuscript received in The Laryngoscope Office and accepted for publication March 19 1959

that our descendants, a thousand generations hence, will ever see eradication of all congenital deformities or all allergies"

By the same token, we can only hope there will be definite progress in the field of trigeminal neuralgia, and that the cause back of this lancinating, excruciating, agonizing, horrible, unbearable pain will be found Trigeminal neuralgia is primarily an affliction of older persons, although it may occur at any age It must be remembered, that as we have more elderly people and especially elderly women, we will be confronted oftener with this painful condition causing lancinating, paroxysmal pain in one or more branches of the Vth cranial nerve This is, indeed, a new frontier to conquer

Only certain specialized nerve endings are capable of receiving pain stimuli The trigeminal nerve is composed of both sensory and motor fibers, the motor fibers are distributed to the muscles of mastication The sensory fibers through the three branches of the nerve are distributed over the forehead, cheek, nose and mandible, and in front of and superior to the ear

The sensory nuclei of the trigeminal nerve extends over the entire length of the mesencephalon and rhomencephalon The main sensory nucleus, transmitting touch sensations, is in the region of the pons The muscles of mastication are the temporals, masseters and pterygoids

It has been stated that the occurrence of trigeminal neuralgia, as an early symptom associated with multiple sclerosis, has long been noted The simultaneous unrelated occurrence of these two conditions in the same individual seems worth investigating

Motor root supplies the masseter, temporal, internal and external pterygoids and the tensor tympani, tensor palati, mylohyoid and anterior belly of the digastric The second branch of the trigeminal, from the sensory standpoint, sends root fibers into the pons, which descend in the medulla to the second cervical segment of the spinal cord, the ophthalmic division descending farthest The Gasserian ganglion, which lies on the petrous portion of the temporal bone in the middle cranial fossa, divides into an ophthalmic, maxillary and mandibular division The lingual branch of the mandibular carries the taste fibers of the chorda tympani The ophthalmic nerve gives off sympathetic fibers to the lacrimal gland The trigeminal stands in relation to the VIIth nerve by means of the sphenopalatine ganglion, and the glossopharyngeal by way of the otic, it is also connected with the facial by means of the large and small superficial petrosal nerves Besides supplying sensory fibers to the face, temple, forehead and anterior part of the scalp, it also innervates the external ear in part (not the whole internal meatus, which is supplied partly by the facial, and the vagus), and it supplies the cornea (pain and not touch fibers), conjunctiva, lingual, gingival, buccal, upper pharyngeal and nasal mucous membrane, the middle ear and the dura Deep facial sensation runs in the facial nerve

OCCURRENCE

Harris reports a patient on whom he did a Gasserian ganglion injection at the age of four-and-a-half years She had been suffering since the age of 16 months from frequently repeated daily spasms of pain, lasting a few seconds only, and referred to the left lower jaw up to the ear

There have been a few cases reported, prior to and in the teenage period, but this is extremely rare The upper limit of age, of course, is even toward nonegenarians Most cases, however, are elderly, edentulous females The ratio of females over males is approximately three or four to one Two per cent of cases are bilateral Trigeminal neuralgia may occur more specifically with glossopharyngeal neuralgia concomitantly and with other facial neuralgias

ETIOLOGY AND PATHOLOGY

1 Neurovascular

2 Traction (dura), (constricting dural bands along the bony petrous ridge)

3 Emotional—psychic

4 Infectious, sinusitis, dental, systemic

5 Disseminated sclerosis, multiple sclerosis

6 Tumors (meningiomas, acoustic neuromas, pearly body tumors)

7 Exposure to cold

DISCUSSION

Undoubtedly the neurovascular mechanism, with the adjacent internal carotid artery and its branches, has a definite bearing on the cause of tic douloureux The fact that the operation devised by Taarnhoj in 1952, showing that there is traction on the dura with constriction of the dural bands along the bony petrous ridge, is significant and may be connected with the neurovascular mechanism, apparently causing pressure on the Gasserian ganglion.

Emotional After the inception of this excruciating pain the psychic element is unquestionably present The grimaces, the fear, the anticipated torture are profound

Foci of infection, especially dental and sinus in nature, and involvement of the temporomandibular joint from an arthritic standpoint, may be contributing factors All sinuses and mouths should be X-rayed, regardless of whether or not they are edentulous Probably over 20 per cent of all edentulous mouths have embedded tooth roots around which are infectious processes in most cases

General systemic infectious disease may be an associated factor It has long been known that multiple sclerosis is oftentimes found in cases of trigeminal neuralgia, and, of course, tumors (meningiomas, acoustic neuromas, pearly body tumors) and aneurysms of the carotid and other intracranial masses may be involved

Although it is a controversial issue, changes in heat and cold, exposure to cold, both externally and intraorally, have a bearing on the inception of this disease

DIFFERENTIAL DIAGNOSIS

The following are the most frequently found conditions which simulate trigeminal neuralgia, and which must be ruled out

1 Sinusitis

2 Dental involvement (embedded third molars), edentulous mouths

3 Glossopharyngeal neuralgia

4 Temporal arteritis

5 Nasal septal spur neuralgia

6 Sphenopalatine ganglion neuralgia*

7 Horton's histamine cephalalgia

8 Costen's syndrome—temporomandibular joint

9 Furunculosis of the ear canal

10 Geniculate ganglion neuralgia

11 Glaucoma

12 Intracranial tumors

13 Trigeminal neuralgia—not tic douloureux (Dandy)

14 Migrainous neuralgia—*Harris*

Sinusitis Greatest pain is early in the morning and on one side, it subsides toward noon and may be bilateral

Glossopharyngeal Neuralgia Love states "If the patient complains of spasmodic excruciating pain that extends from the pharynx and tonsillar fossa on one side to the homolateral ear, and the pain is precipitated by swallowing, talking or yawning, the examiner can be rather certain that the patient has glossopharyngeal or IXth nerve neuralgia If the examiner desires further proof of the diagnosis, the involved side of the pharynx and the tonsil may be cocainized and the patient given a glass of water If on drinking, no pain is produced, the diagnosis is confirmed Cocainization of the throat has no effect on neuralgia of the third branch of the Vth nerve Likewise, injection of alcohol into the third branch of the Vth nerve has no effect on glossopharyngeal neuralgia"

Temporal arteritis has a flushing and perspiration, and usually responds to steroid treatment It may be associated with the temporomandibular joint Most of the others in this

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*Sphenopalatine ganglion neuralgia is a misnomer This should be deleted from the literature

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TREATMENT INJECTION THERAPY

1 Procaine hydrochloride

2 Absolute alcohol 95 per cent

3 Supraorbital, infraorbital, mental

4 Deep alcohol injection or infiltration maxillary and mandibular branches at base of skull

5 In Gasserian ganglion contraindicated

There are some hazards in connection with the injection of absolute alcohol 95 per cent into a nerve body or foramen, because of the possibility of sloughing tissues, involvement of the adjacent nerves, and alcohol has also been accidentally injected intravenously There are many advocates of alcohol injection, but there is danger in injecting the Gasserian ganglion

ALCOHOL INJECTION ADVANTAGES ARE

1 Poor risk patient—elderly, cardiovascular-renal complications

2 In younger patient to ascertain status and possibly spontaneous remission

3 To confirm diagnosis (possible atypical neuralgia)

4 To ascertain premonitory warning of organic lesion

5 To promote temporary freedom of pain—patient's general hygiene improvement

ALCOHOL INJECTION DISADVANTAGES ARE

1 Sloughing tissues

2 Alcoholic neuritis

3 Burning paresthesias

4 Continued repeated injections

5 Never do deep injection of first division

6 Inadvertent subarachnoid infiltration

differential diagnosis can be determined by careful anamnesis, together with X-ray, laboratory and other findings

DIAGNOSIS

1 Elderly patient (female) (edentulous)

2 Agonizing unbearable pain, paroxysmal in nature

3 Trigger zone—ala nasi, upper lip, buccal mucous membrane

4 Dietary deficiency and dehydration—lack of nourishment

5 Seasonal exacerbation (Spring and Fall)

6 Careful anamnesis

7 Patient's description of pain

8 The grimaces and fear mentioned above

QUESTIONABLE THERAPY

When considering medical and temporizing surgical therapy which gives temporary relief we may lull ourselves into complacency and distort the true picture

MEDICAL THERAPY

All of the following have been tried from a medical standpoint and many articles show that in the hands of a certain doctor they seem to have proven efficacious There is always a question as to whether the patient had a true trigeminal neuralgia

1 Dilantin sodium

2 Priscoline

3 Histamines (vasodilators)

4 Nicotinic acid

5 Stilbamidine isethionate (taken off of market)

6 Vitamin B_{12}, vitamin B_6

7 Steroid therapy

8 Ataraxoid—Tranquilizing preparations

9 Narcotics and allied drugs

10 Protamide

5 Fourth nerve (trochlear) paresis

6 Herpetiform vesicles—eyelids

7 Keratitis neuroparalytics

8 Nerve deafness

9 Paralysis of motor trigeminal and facial (usually temporary with facial but may be permanent with nerve deafness)

10 Diminshed secretions of tears

Of the above, undoubtedly the corneal involvement through its desensitization with a subsequent keratitis is tremendously significant Many of the others may be equally as significant, but they are found less frequently In the corneal desensitization the ophthalmic branch, naturally, has been sectioned

GENERAL CONSIDERATIONS

1 Inadequately fed, dehydrated, nervous

2 Apprehensive, pain-wracked, debilitated

3 Subclinical dietary deficiency, prolonged bleeding time

4 Protein-poor dehydrated patients—wounds heal poorly

5 Blood electrolyte patterns abnormal

6 Mental confusion—retraction of temporal lobe

7 Blood urea nitrogen—fluid balance

8 Liquid intake and urinary output

9 Restlessness, apprehension, depression

10 Barbiturates, adverse reaction—disorientation

11 Considerate thoughtful attention from surgeons

One must carefully evaluate each one of these and be a psychiatrist par excellence, a keen internist and equally capable surgeon, besides being a philosopher

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SURGICAL THERAPY

1 Peripheral—middle cranial fossa—centrally, *a* Superficial foramina in face, nerve crushed or avulsed, *b* transtemporal craniectomy—Gasserian ganglion middle cranial fossa, *c* posterior sensory root—tractotomy (mesencephalon-medulla oblongata)

The branches of the trigeminal nerve may be cut either centrally in the Gasserian ganglion or at various branches, infraorbital, mandibular foramen, mental foramen, et cetera

The transtemporal craniectomy devised by Taarnhoj, and exemplified by Love and Woolsey, has its advocates and certainly is to be commended

The tractotomy operation involving the mesencephalon-medulla oblongata severing the posterior sensory root may be performed by careful neurosurgeons The transtemporal retrogasserian sensory root section by Frazier and Spiller has probably been performed more than most of the others I am not familiar with Kirschner's electrocoagulation of the Gasserian ganglion, but it sounds like it might have merit

Jaeger's hot water injection through the foramen ovale with complete destruction has no untoward results, no anesthesia of the eye, no involvement of other nerves, and it may be a great contribution Jaeger reports 130 patients in whom there have been no deaths, no facial paralysis, and no other complications He states that this should be performed by a neurosurgeon It is my opinion that the training in otolaryngology should include not only the ability to inject through the foramen ovale with hot water, but to resect the sensory root (maxillary and mandibular) of the trifacial nerve

COMPLICATIONS—NEUROLOGIC DEFICIT

1 Anesthesia of face (substitute for agonizing paroxysms of pain)

2 Corneal desensitization

3 Lagophthalmos

4 Abducens nerve palsy

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AMERICAN ASSOCIATION FOR CLEFT PALATE REHABILITATION

The American Association for Cleft Palate Rehabilitation will hold its Eighteenth Annual Convention at the Brown Palace Hotel, Denver, Colo, Thursday, Friday and Saturday, May 12, 13 and 14, 1960

This Association is composed of medical, dental and paramedical specialists who are interested in the rehabilitation of persons with cleft lips and palates

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ing this organ, and undoubtedly has been a great source of reassurance for many surgeons assaying a parotid dissection One would feel more confident in beginning his dissection if he knew that there was a natural plane of cleavage that he was dealing with, rather than the concept of McKenzie, of a vine weaving itself around a trellis

Patey, in 1957, reviewed the surgical anatomy of the parotid gland and on the basis of his surgical and anatomical dissections proposed a new concept of division of the parotid He proposed an anatomical surgical plane that was based upon the anatomy of the large veins which transverse the gland from above downward Th eposterior facial veins, starting with the superficial temporal vessels at the upper border of the gland, pass through the substance of the gland on a plane just immediately deep to the facial nerve, and end at the lower pole of the parotid as the anterior facial vein and the posterior facial vein The veins establish a definite anatomical plane throughout the entire gland Patey has called this the facio-venous plane, and by keeping superficial to it throughout the dissection, the cleavage develops between the superficial and deep portion throughout the gland

The practical value of this concept is that by so splitting the gland the venous circulation is not interrupted during the dissection of the superficial portion This greatly reduces the bleeding which is for the great part venous oozing, which occurs when the lower pole of the parotid is dissected first and the posterior facial vein is cut and tied, and the glandular tissue becomes congested due to venous stasis

The second practical application of the facio-venous plane is that it permits a more accurate description of the operative procedure Thus, Patey divides the gland into a superficial portion which he names the superfacial, and a deep portion which he names the subfacial Each of these two major portions are then divided into an upper and lower half called the suprafacial and the infrafacial The surgeon, then, in describing a partial parotidectomy can accurately define the amount and location of the tissue which has been removed and the portion which remains

TOTAL PAROTIDECTOMY*

JOHN F DALY, M D,

New York, N Y

A great deal of progress has been made in surgery of the parotid gland since the turn of the Century In the early editions of "Treves," that small but mighty compendium of surgical anatomical knowledge, the complete removal of the parotid gland was described as a surgical impossibility Paradoxically, the progress that has been made since that time has been based on an erroneous concept of the structure of the gland, namely, that it is a bilobed organ

Gregoire, in 1912, was the first to describe it as a bilobed organ McWhorter, in 1917, supported this idea and indicated that the isthmus was located between the two main divisions of the facial nerve, namely, the cervico-facial and the temporo-facial divisions Bailey, in 1941, developed the idea further and claimed that there was a natural plane of cleavage between the two lobes that was easily identifiable and in which the facial nerve was found He further stated that the only portion of the gland that had to be divided was the isthmus, which he located between the two divisions of the facial nerve Martin, in 1952, in commenting on the plane of cleavage, doubted that there was such an anatomical plane but retained the nomenclature of a superficial and deep lobe in his descriptions

McKenzie, in 1948, basing his conclusions on anatomical studies, showed that the gland was not bilobed with a single isthmus, but that it had multiple isthmi, in fact, he compared the gland to a creeping vine, weaving itself into the meshes of a trellis, the facial nerve

The concept of the bilobed structure of the gland with a natural plane of cleavage has dominated our thinking regard-

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SPONTANEOUS CEREBROSPINAL OTORRHEA

Report of a Case With Successful Surgical Repair[*]

BEN R DYSART, M D,
Pasadena, Calif

Cases of spontaneous cerebrospinal otorrhea are so rare that they may be considered a medical curiosity I am presenting a case which occurred in a woman of 72 years While many cases of cerebrospinal otorrhea, which followed trauma or operations, have been reported, only one reference could be found of a case at all similar This was a case reported by O R Kline[1] in 1933 His patient was a man of 54 who suddenly began to drain clear fluid from an apparently normal ear on leaning over to pick up an object He developed meningitis and died three days after the onset of drainage The autopsy showed what was probably a congenital fistula that had begun to drain without apparent reason A slightly similar case was reported by Nenzelius,[2] of Sweden, his case was a 15-month-old girl with a number of other congenital malformations She was cured after three operations and three recurring attacks of meningitis His search of the literature found one other case reported by Eschat[3] in 1897 I was unable to get a copy of this report

Case Report A white woman of 72 was first seen by me on July 1, 1955 There had been a painless, watery drainage for two months without intermission Seven months before, there had been a very slight painless drainage for two days Trauma and recent infections were denied About 35 years before, she had had a painful infection of the right ear that had recovered after an incision of the drum, followed by drainage for a few days She thought her hearing was normal, but the audiogram showed about 20 db loss for conversational tones in both ears Examination showed a small central perforation of the right drum in the posterior inferior quadrant, through which a clear watery fluid constantly drained Tests showed 75 mg per cent of sugar which indicated cerebrospinal fluid X-rays showed both mastoids well pneumatized with some pneumatization of the petrous tips There was slight clouding of the right mastoid, but no other abnormality was seen The amount of drainage would vary from day to day On one day 5 cc were collected in an hour and a half, this was about average

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[*] Read at the Meeting of the Western Section of the American Laryngological Rhinological and Otological Society Jan 17 1959

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The term total parotidectomy is used to describe a complete removal of the parotid tissue This may be indicated in benign conditions such as the cystadenolymphomatosum and also sialectasia, or a total parotidectomy may be done when an exposure of a mixed tumor arising in the deep portion of the gland requires removal of both the superfacial and the subfacial portion The term radical has been applied to total parotidectomy when the facial nerve has been sacrificed in its entirety, and conservative when it is possible to remove part of the gland and preserve all or part of the facial nerve

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PAN-PACIFIC SURGICAL ASSOCIATION

The Eighth Congress of the Pan-Pacific Surgical Association will be held in Honolulu, Hawaii, September 28 through October 5, in 1960

All members of the profession are cordially invited to attend and are urged to make arrangements as soon as possible if they wish to be assured of adequate facilities

An outstanding scientific program by leading surgeons promises to be of interest to all doctors Nine surgical specialty sections are held simultaneously

Further information and brochures may be obtained by writing to Dr F J Pinkerton, Director General of the Pan-Pacific Surgical Association, Suite 230, Alexander Young Building, Honolulu 13, Hawaii

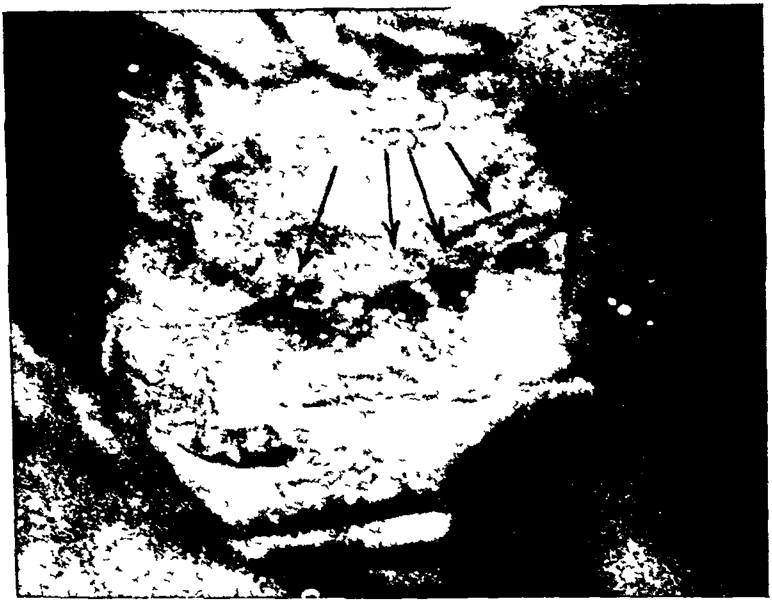

Fig 2 Photograph taken at operation showing 'craters in the anterior face of the temporal bone

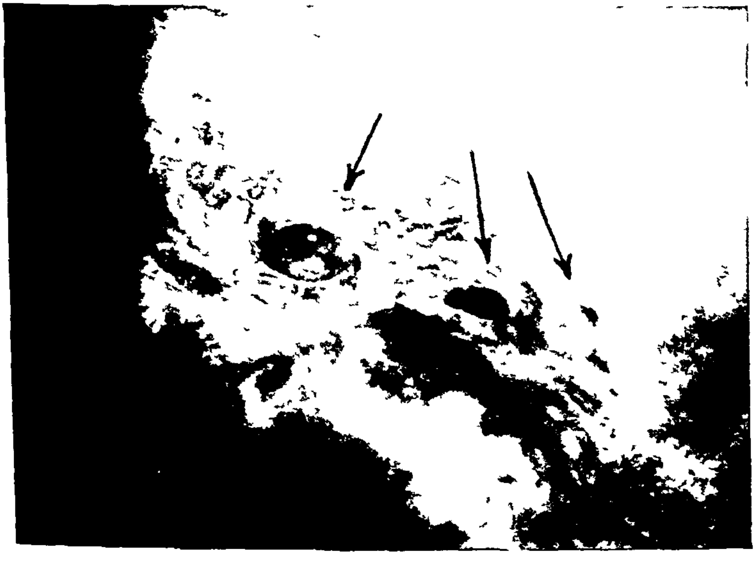

Fig 3 Photograph taken at autopsy of craters in anterior face of the left temporal bone

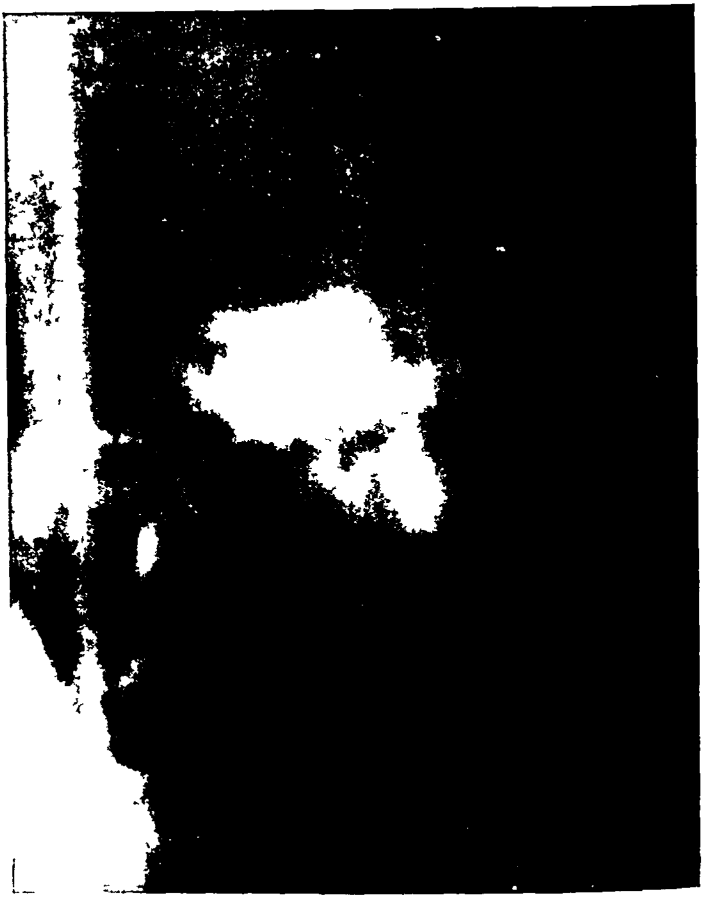

Fig 1 Laminographic X-ray of right temporal bone showing defect lateral to arcuate eminence

At first, the patient could not be persuaded to consider an operation, but finally after five months of continuous drainage she entered the hospital She had known for a long time she had severe nephritis and a hypertension of 200/100 Neurological examination was negative Laminographic X-rays showed a possible defect in the tegmen on the anterior edge of the right temporal bone just lateral to and anterior to the arcuate eminence (see Fig 1)

Exploratory operation of the anterior face of the temporal bone was done Nov 1, 1955, by our neurosurgeon, R H Pudenz, M D A circular piece of the temporal bone about 3 cm in diameter was removed, and the dura stripped from the anterior slope of the petrous bone In this bone was found five or six crater like structures, the largest of which was 5 or 6 mm in diameter (see Fig 2) The dura was rigidly attached to them, and when it was stripped away there was an opening made through which cerebrospinal fluid escaped In the largest of these craters was seen some soft gray tissue which was taken for biopsy This was later

2 Nenzelius, Carl Spontaneous Cerebrospinal Otorrhea Due to Congenital Malformations *Acta Oto Laryngol*, 39 314 328, Aug, 1951

3 Eschat *Arch Internat de Laryng*, 10 653 659, 1897

GILL MEMORIAL EYE, EAR AND THROAT HOSPITAL

The Gill Memorial Eye, Ear and Throat Hospital has just completed its Thirty-second Annual Spring Congress in Ophthalmology, Otolaryngology and allied specialties The attendance was one of the largest in the history of the school with an attendance of 350 physicians and their wives There were forty-two states, England, Canada and several foreign countries represented There were twenty-one guest speakers, sixty lectures and closed circuit televised surgery during the five and one-half days of the Spring Congress In 1960, the Thirty-third Annual Spring Congress will be held from April 4 through April 9

reported as nerve tissue of cerebral type A flap of temporal muscle about 2 cm in diameter was then cut and spread over the craters and sutured to the deep dura in three places The incision was closed rapidly, as the blood pressure had dropped from 200/100 to 60/40 Transfusion was started at once, and the pressure came back to 160/90 before she left the room

Postoperative Course The patient recovered rapidly and there was never any more drainage from the ear She died 18 months later following a thrombosis of the right middle cerebral artery

Autopsy Many of the previously described craters were found in the floor of both temporal fossae, more on the right side than the left (see Fig 3) They were present from the anterior limits of the middle fossa to the extreme posterior portion of the temporal lobes Minute projections of brain tissue, covered by dura, extended down into these craters

Microscopic appearance "Sections of the temporal and sphenoid bone show within what one would normally expect to be marrow spaces, nodular protrusions of glial tissue, somewhat resembling normal cortex but showing fewer cell bodies Buds of tissue protruded off the larger masses to extend into lacunae The dura appears to be perforated in these areas, and only a thin investment, apparently pia, covers the nervous tissue protrusions There is no apparent reaction surrounding the masses"

Otherwise, the autopsy showed some softening of the brain, supplied by the thrombosed right middle cerebral artery, generalized arteriosclerosis and chronic pyelonephritis In his discussion the pathologist said "The extension of dura and brain substance into the temporal bone is unique, and we have not as yet run across a description of this condition anywhere"

DISCUSSION

The temporal bones were removed and sent to Dr Victor Goodhill's research laboratory In sections of these bones A A Krajian, Ph D, saw numerous clusters of cells which he thinks are kala-azar organisms The patient's last physician remembered that she had been twice around the world many years ago, and at one time had a febrile infection diagnosed as malaria Several pathologists have checked the same slides, and do not think that these cells are protozoons I am inclined to agree with Drs Shillam, Foord and Fisher, that the defects found in the temporal bones were developmental anomalies Why one of them developed a leak down into the ear I do not know I compliment our neurosurgeon, R H Pudenz, on finding the defect and successfully repairing it

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clearly functional problems such as hysterical dysphonia and persistent prepubital voice at the other end

The majority of voice problems will be found to fall within these extremes Cause and effect are so intricately interwoven that it is usually impossible to solve the "which comes first" riddle Vocal folds which are irritated by acute or chronic infections or allergic reactions will take abuse more readily, on the other hand, vocal folds which are irritated constantly by misuse are more apt to suffer organic changes

It is not our purpose to catalog the myriad characteristics of faulty vocal production to be found in the total population of patients with voice problems The most common are *1* harsh initiation of vocal tones, *2* faulty pitch placement, *3* restriction of pitch range, and *4* imbalance of vocal resonance Almost inevitably, these characteristics will not occur singly, but together, in varying degrees

Harsh vocal attack is probably the single factor most commonly found It is usually heard as a "glottic shock" or "glottic stroke," in which vowel sounds are initiated with a click and give a harsh, rattling quality to the voice A number of primary factors are present in the production of the harsh vocal attack, but these all lead to the secondary factor of tension within the laryngeal musculature As a consequence of this tension, the vocal folds adduct to initiate phonation with a sharp catch rather than producing a full, smooth tone

In the second characteristic, faulty pitch placement, the architecture of an individual's vocal mechanism—its component parts, their size, shape, tissue characteristics, etc, will generally determine the most efficient or optimum pitch range at which the individual's voice will function Problems may occur when the individual consciously or unconsciously chooses to use the voice habitually outside or at one of the extremes of his natural pitch range

The restriction of pitch range is closely related to faulty pitch placement and is also associated with tension In this problem, the normal pitch variations which produce the inflections of ordinary discourse do not occur or are limited in extent, and the voice becomes flat and monotonous Usually,

VOICE TRAINING IN THE MANAGEMENT OF DYSPHONIA *†

RICHARD M FLOWER, Ph D ,
(By Invitation),
San Francisco, Calif

The speech therapist will approach any problem of dysphonia in a manner somewhat different from the laryngologist In the sense of effecting improved organic status, treatment is not the basic function of the speech therapist, it is his task to work within whatever limitations are imposed by organic problems and to help the patient to achieve the most acceptable function with the least strain on his physical equipment Organic equipment may become healthier as the result of relief from the strain of misuse, but improvement of function remains the principal goal Our remarks will be concerned with three things characteristics of vocal function found frequently among patients with voice problems, general approaches to these problems within the discipline of speech therapy, and considerations in the prognosis for improvement through voice training

Faulty vocal function cannot be separated from the human being who directs the function The human voice itself is one of the best indices of the way the human feels It expresses the feelings of the moment as well as the perennial patterns of adjustment of the individual There is no reason here to dichotomize any complex aspect of human behavior into that labelled "functional" or "organic" The functional versus organic breakdown must properly be considered as a continuum, with the clear organic deficiencies such as dysphonias resulting from the surgical removal of all or a portion of a vocal fold, or vocal fold paralysis at one end, and the

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*Read at the Meeting of the Western Section of the American Laryngological Rhinological and Otological Society, Jan 17 1959

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The restriction of pitch range is closely related to faulty pitch placement and is also associated with tension In this problem, the normal pitch variations which produce the inflections of ordinary discourse do not occur or are limited in extent, and the voice becomes flat and monotonous Usually, only the three or four tones at the lower end of the pitch range are used The use of this characteristic is common on the stage, when an actor attempts to convey the concealment of emotional response

Resonance of the human voice occurs chiefly in the pharyngeal, oral, and nasal cavities In the normal voice, some degree of participation of each of these resonators is present throughout phonation, however, it must be in "balance" Problems occur when resonation in one of these cavities is excessive or when it is diminished The accentuation of pharyngeal or nasal resonance is common among dysphonic patients

The following sequence of objectives in voice training or re-training are summarized briefly, even though many variations result from the idiosyncrasies of each individual patient and his problem

1 Simple initiation and production of a full tone within the optimum pitch range, clear in quality, and in which the various resonance components are in proper balance

2 The ability to utilize this vocal tone spontaneously, with auditory and kinesthetic monitoring, and with recognition of the differences between the new tone and the habitual manner of vocal production

3 The ability to utilize this tone in increasingly longer language units—from the syllable, to the word, to the phrase, to the sentence, and to longer passages

4 The use of more acceptable voice in the activities of daily living

Many methods are used in the achievement of improved vocal tones These techniques are directed at providing adequate breath support for vocalization, determination of the point at which abrupt adduction of the vocal folds occurs, replacement of this sharp adduction with smoother vocal fold contact, and restoration of balance in resonation

Retraining of vocal pitch has been deliberately omitted from discussion here, since faulty pitch placement is usually treated as a secondary rather than a primary factor Although it is mentioned as a common trait among patients with voice disorders, faulty pitch placement is usually only one evidence of faulty phonation Mere pitch change does very little to change the basic fault in vocal production When a clear, fluid vocal tone is achieved, the pitch usually automatically changes to the approximate optimum If the problem of pitch is attacked separately, it is more easily approached after improved phonation is achieved

In the therapy sequence, emphasis is placed on assisting the individual to recognize exactly what he is doing in the production of his voice When confronted for the first time with a tape recording of his own voice, almost any person will deny its veracity, this denial is even stronger in the presence of a voice problem

We monitor our voices auditorially, the deterioration of voice quality commonly heard in a deafened adult will offer ample evidence of this We also monitor our voices kinesthetically This can be demonstrated by introducing sufficient masking noise into the ears to block out all side tones Usually, even though volume increases, the voice quality changes are minimal The relationship between muscular tension and voice disorders is a pertinent one here Tension can be perceived only as a kinesthetic experience From the beginning of the training period, the therapist must stress constant and accurate monitoring of each vocal production

The process of assisting an individual to use this improved vocal production in his daily discourse is more complex than an admonition Of primary importance is the individual's willingness to change and his ability to focus his efforts on the amelioration of the voice problem The surgeon requires only the physical presence of a patient for the treatment of a problem, but the speech therapist can offer the patient only a variety of activities which may effect functional improvement and act as a guide Changes are effected by the patient himself Once improved phonation is achieved in the therapy session, it is the sole responsibility of the patient as to whether it is carried outside of the speech clinic The speech therapist can assist the patient in recognizing those factors which prevent his use of improved phonation in the world outside of the clinic, in the hope that the patient can work out his own solutions to the interferences When these interferences represent complex neurotic manifestations, the patient should be referred to a psychotherapist

Laryngologists have often asked for suggested techniques which might be used during an office visit to effect improved vocal usage This is difficult The referral from laryngologist to speech therapist, and back again to the laryngologist, can be a very clumsy process There would be many advantages to combined medical treatment and voice training by one individual, however, the problems involved are very practical The alteration of firmly fixed vocal habits often requires semi-weekly contact between therapist and patient for a period ranging from three to six months, or more The schedules of most laryngologists seldom permit this amount of time to be given to any single patient

When dealing with the results of any procedure as difficult to objectify as voice training, we can only estimate prognosis on the basis of our own experience Our views of prognosis are presented here on the basis of a review of a series of 50 patients with whom we have worked during the past five years The patients reviewed were selected only on the basis of the criteria that continued contacts with the speech clinic were maintained for a period of at least six months and that a reexamination by the referring laryngologist was available at least six months following termination of voice training In several instances reexamination one year following termination of therapy were available Voice training was considered successful when a more acceptable voice was achieved and maintained, and when there was no evidence of misuse on laryngeal examination at the six months' recheck

Among this relatively unselected clinical population, 25 patients achieved success according to the stated criteria Published reports by Williamson[1] claim success with 61 out of 69 patients, Peacher[2] reports success with five out of six patients with contact ulcers, and Gardner[3] describes success in the treatment of all 37 of his patients with what he calls "executive's dysphonia" It is our impression that in routine clinic practice the degree of success met is seldom as high as claimed by these writers

Further examination of our patient records leads to these additional conclusions regarding prognosis

1 Barring irreversible pathology or structural anomaly of the vocal mechanism, the reported condition of the larynx is an unsatisfactory measure of prediction of ultimate success in retraining The prognosis remains about the same whether the larynx appears essentially normal, whether inflammation is present, or whether nodes, nodules, contact ulcers, etc, have developed

2 The adult patient's age does not predict his probable success in retraining, except for the voice changes of senescence The patient of 50 years may be as amenable to voice change as the patient of 20 years, however, pre-adolescents who have developed dysphonias as the result of vocal abuse present extremely difficult problems for voice training The degree of concentration, critical listening, and self-supervision which the process demands can seldom be expected in childhood

3 Voice disorders which are ordinarily associated with misuse are not found exclusively among people in professions which demand constant voice use (*e g*, law, the ministry, teaching, etc) On the other hand, the fact that voice usage is essential to an individual's vocation is no insurance that he will succeed in voice retraining—in the author's experience, again only approximately one-half achieve lasting improvement

4 Although a somewhat higher number of women than men come to our clinic seeking voice therapy (the ratio is four to three in our population) significantly fewer women than men achieve success in voice training It is generally believed that most hysterical conversions have a somewhat higher incidence among women It is possible, therefore, that more of the voice disorders found among women are manifestations of complex problems of adjustment, and as such, are given up much less readily

5 No other specific prognostic factors, such as thyroid disorders, foreign dialect influence, or the length of time since the initial awareness of the voice problem, seem to yield information of any certainty in the prediction of potential success in voice training

It is probable that the really significant characteristics of a patient which will predict whether voice training will be successful are those which cannot be objectified An ideal candidate is an individual who is sufficiently intelligent and secure to be insightful, who can learn to listen critically, who is able to approach his problem directly, and who is willing to direct real effort toward the difficult task of changing long-standing habit patterns Conversely, the least likely candidate is the patient who finds insight difficult or threatening, who cannot permit himself to listen honestly, who may protect himself by scattering his attention, and who cannot muster his efforts to work diligently for improvent We are again confronted with two ends of a continuum, between these ends falls the majority of the patients

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THE RADIOLOGIC STUDY OF SOME NORMAL AND ABNORMAL SWALLOWING MECHANISMS, ASPIRATION PHENOMENA AND CRICOPHARYNGEUS SPASM[*][†]

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Advanced carcinoma of the larynx, hypopharynx and thyroid are frequently associated with dysphagia and aspiration phenomena. The roentgenologist is requested to determine whether the aspiration is due to fistula formation or occurs through the normal laryngeal channel. In order to make this differentiation, an adequate roentgenographic visualization of the laryngopharynx during the second stage of swallowing is required. Routine conventional procedures are usually found inadequate because of the rapid sequence of events in this region during deglutition. Single, sporadic exposures of the barium-opacified laryngopharynx during swallowing do not yield the desired information concerning the abnormal mechanism involved. For this reason it was decided to use a somewhat more elaborate technique in the study of deglutition. A Fairchild rapid changer was employed which yielded 9x9 inch roentgenograms of the laryngopharynx up to a rate of two per second.

The results with this apparatus were found highly satisfactory after some experience had been obtained. The 9x9 inch films produced life size images permitting analysis in very fine detail of the various portions of the larynx and hypopharynx during swallowing. Such detailed visualization was found essential in obtaining a proper understanding of the mechanisms involved in normal and abnormal swallowing. The other instrument which has been employed recently in

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[†] From the Radiology Service of the Francis Delafield Hospital, New York, N.Y.

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the study of deglutition is the cineradiograph, usually carrying 16 mm film The latter apparatus produces pictures at a faster rate, but the detail is very much less than that obtained with the 9x9 inch changer It would appear that the advantages of greater detail may more than offset the greater speed factor of the cineradiograph in the proper interpretation of events in the laryngopharynx during deglutition

ASPIRATION PHENOMENA

In order to understand the radiographic features of abnormal swallowing and aspiration it is necessary to acquaint oneself with the radiographic appearance of the normal anatomy and physiology of swallowing The entrance from the laryngopharynx into the laryngeal vestibule (*i e*, the laryngeal aperture) is bounded in front by the epiglottic rim, on each side by the aryepiglottic folds, and posteriorly by the arytenoid cartilages sliding on the cricoid lamina (see Fig 1) Lateral to the aryepiglottic folds and side walls of the vestibule are the pyriform fossae Our studies indicate that these structures, which rim the laryngeal aperture, form the primary and essentially the sole barrier preventing the passage of fluid from the hypopharynx into the larynx during the second stage of swallowing In our experience to the present time, the true and false cords have never performed as competent safeguards against aspiration In each instance where the barium suspension was able to penetrate the protection ring about the laryngeal aperture and reach the cords, the fluid passed the rima glottidis and entered the trachea The process of swallowing is best studied radiographically with the rapid changer in the lateral view In this position there is the least overlap and barium obscuration of the epiglottis, aryepiglottic folds, arytenoid cartilages, thyroid and cricoid cartilages, bands and cords

An analysis of the radiographs made with the rapid changer at two per second during barium-suspension swallowing, reveals the following sequence of events in the normal laryngopharynx The erect epiglottis, situated behind the posterior aspect of the tongue, acts as a partial barrier and dam in the midline against the passage of fluid from the mouth into the

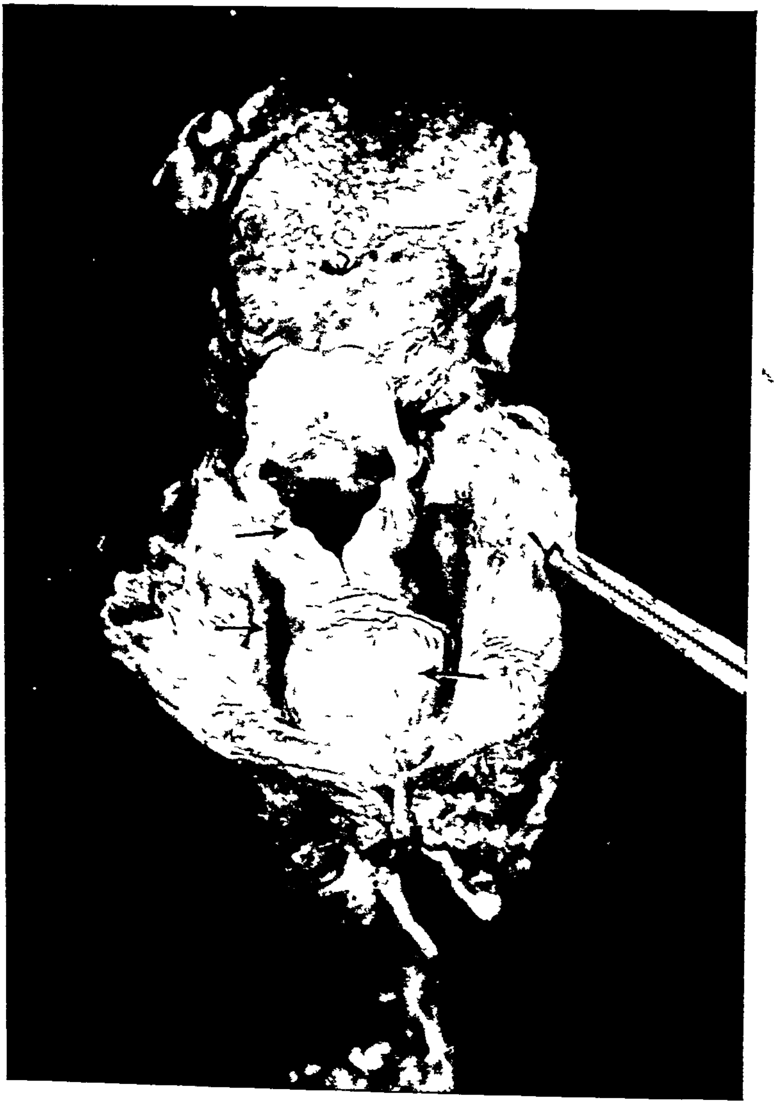

Fig 1 Larynx and laryngopharynx seen from behind Laryngeal aperture well shown Right upper arrow at aryepiglottic fold right lower arrow at pyriform recess left arrow at cricoid lamina

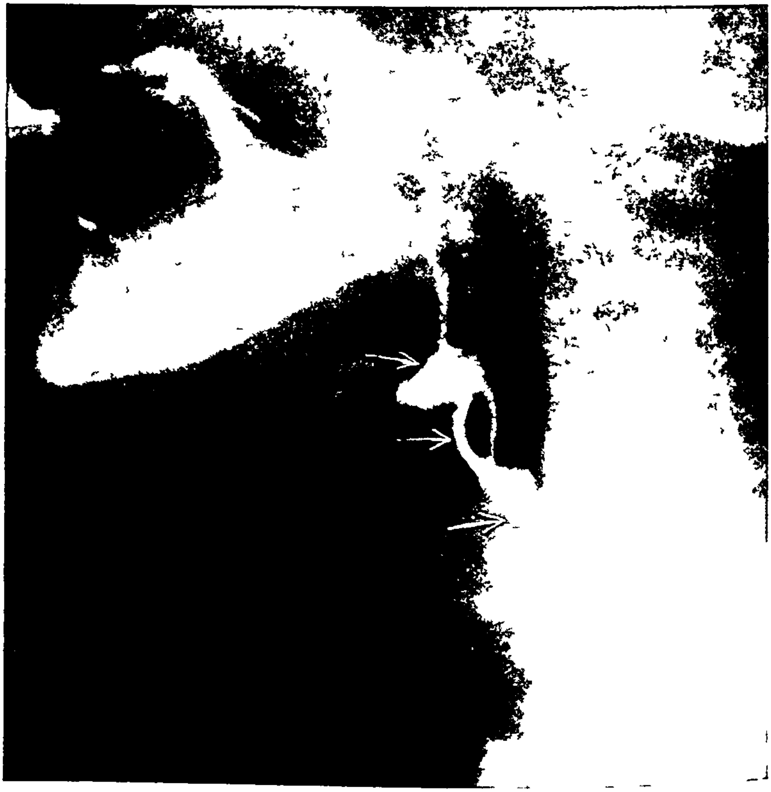

Fig 2 Swallowing of small amounts of fluid Note contrast material spilling around sides of erect epiglottis (upper arrow) running down the pyriform recess trenches on each side (middle arrow) into the esophagus (lower arrow) The aryepiglottic folds remained straight and the laryngeal aperture is open There is no spill into the vestibule

upper pharynx Fluid may enter the pharynx in either of two ways If a small quantity of fluid is ingested it is insufficient in amount to pass over the centrally placed erect epiglottis The fluid flows on each side of the epiglottis and enters the pharynx laterally, passing over the pharyngo-epiglottic folds and flowing in the pyriform recesses on each side of the laryngeal vestibule Because the pharyngeal side walls approximate the laryngeal vestibule at this time, the pyriform recesses assume the form of shallow troughs which channel the small amounts of fluid from the lateral margins of the epiglottis down and around the laryngeal vestibule into the postero-inferior hypopharynx and directly into the esophagus (see Fig 3-a) The laryngeal aperture and airway do not close The two lateral shallow pyriform recess trenches are adequate to direct all of the small amount of ingested fluid into the esophagus, and none of the fluid spills over the troughs into the open laryngeal aperture airway

On the lateral view radiographs, following the swallowing of small quantities of barium suspension, the pyriform recess troughs may be visualized as thin opaque bands extending downward, around and backward from the epiglottis to encircle the open laryngeal aperture and join at the esophagus below the larynx (see Fig 2) The suspension does not spill over the aryepiglottic folds into the vestibule

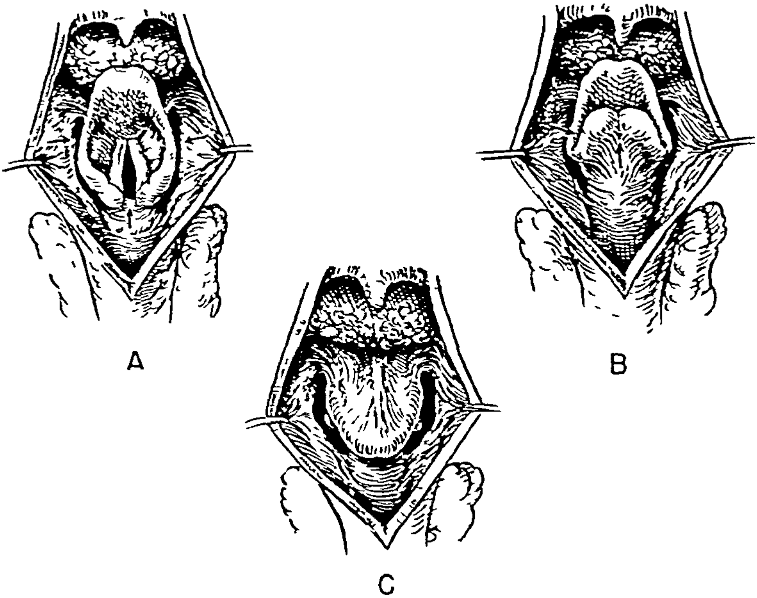

Fig 3 A—Open laryngeal vestibule in resting stage Upper arrows point to pyriform recess trenches on each side of the aryepiglottic folds Lower arrow at open interarytenoid commissure B—Closing of laryngeal vestibule just prior to passage of bolus Lateral arrow points at aryepiglottic fold furrow caused by bending of this fold with elevation of arytenoids Medial arrow points at closed interarytenoid commissure between the elevated arytenoid cartilages which have been pushed against the back of the epiglottic plate C—Epiglottis has been turned backward and downward over the elevated arytenoids by passage of the large bolus over this structure during swallowing

When large amounts of fluid are ingested in a single swallow, the bolus entering the pharynx is too large to be completely channelled in the pyriform recess troughs, and the fluid spills over the aryepiglottic folds onto the larynx. The second, and more important, protective mechanism is then utilized.

The laryngopharynx, in protecting against aspiration during the second stage of swallowing of such a large fluid bolus, follows a comparatively rigid pattern of actions in fixed sequential relationships (see Fig. 3). As the fluid bolus reaches the back of the mouth there is a strong action of the pharyngeal and extrinsic laryngeal muscles which results in a moderate elevation of the hyoid bone and marked elevation of the cricoid and thyroid cartilages so that the latter closely approximate the hyoid bone. As the cricoid cartilage is elevated, the arytenoid (and adjacent corniculate and cuneiform) cartilages which rest on the cricoid lamina are also raised. While ascending, the two arytenoid cartilages approximate each other, closing off the arytenoid commissure. At the peak of their ascent the now-adjacent arytenoids are jammed against the posterior surface of the epiglottic plate below its superior rim, thus effectively sealing off the laryngeal vestibule from the laryngopharynx. With the elevation of the arytenoids toward the epiglottis, the aryepiglottic fold on each side bends at its center so that the superior half of the fold meets the inferior half and seals off the lateral margin of the laryngeal aperture from the lateral laryngopharyngeal passageway.

At the line of apposition of the upper and lower halves of the aryepiglottic fold on each side a thin furrow is formed (see Fig. 3-b). Frequently, a small amount of barium suspension will become lodged in each of the two furrows and appear as two thin, opaque lines projecting forward from the elevated arytenoid cartilaginous mass areas in the lateral roentgenograms made during swallowing (see Fig. 4). The manner of closure of the laryngeal aperture described above was seen in all the normal cases studied. A purse-string-like closure, thought by some to be the mechanism employed, was not observed. Anatomically, the comparatively broad rigid expanse of the epiglottic cartilaginous plate, the thick masses of the arytenoids and the exceedingly poor musculature at the rim

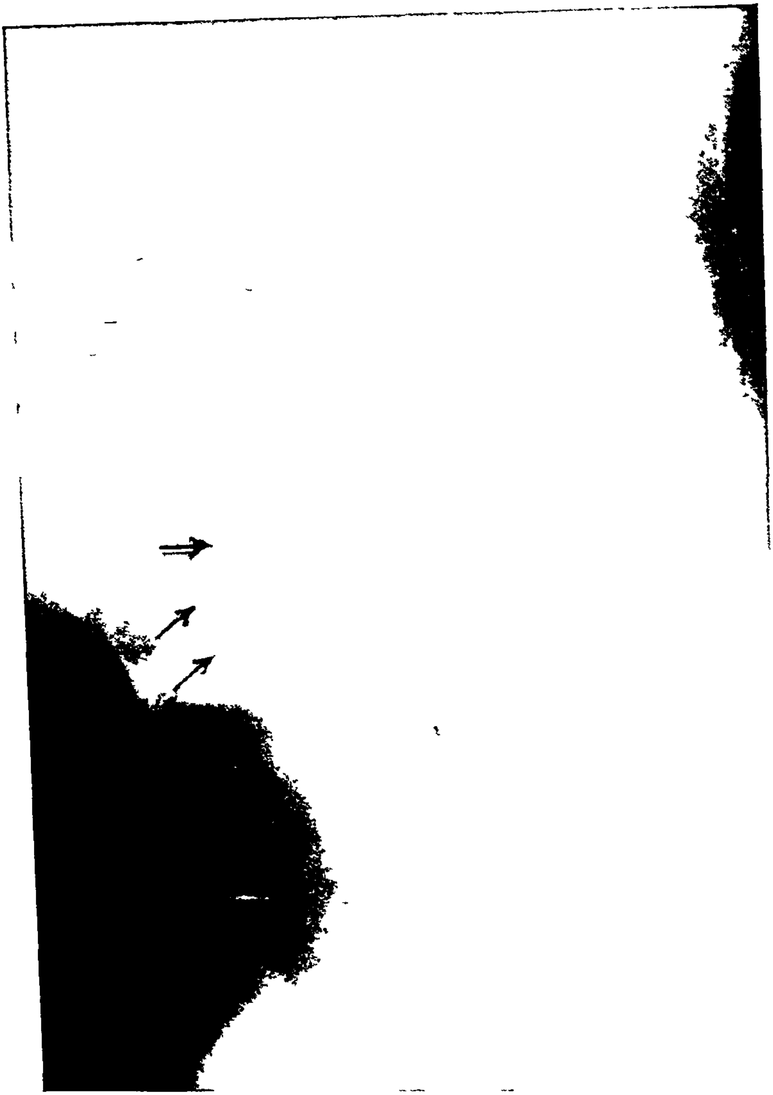

Fig 4 Lateral view of laryngopharynx following barium opacification Upper arrow at turned-down epiglottis middle arrow points to opaque lines of barium in the aryepiglottic fold furrows lower arrow at filling defect caused by elevated arytenoid cartilages

of the laryngeal aperture make almost impossible a purse-string closure wherein all elements contract in size significantly

Following the preparatory elevation of the larynx and closure of the laryngeal aperture, the large fluid bolus in the back of the mouth is now pushed down into the laryngopharynx Part of the fluid passes on each side of the epiglottis into the lateral pharyngeal passageways and then downward, posteriorly and medially, into the esophagus The fluid is prevented from entering the lateral aspects of the laryngeal aperture by the closed aryepiglottic fold furrows The major portion of the fluid passes directly over the erect epiglottic tip The strongly propelled large fluid bolus causes the epiglottic rim to be bent backward on itself over the closed laryngeal aperture, and it comes to lie over the elevated mass of the arytenoid cartilages which have been pushed against the back of the epiglottic plate (see Fig 3-c) This backward bending of the epiglottis is not an essential factor in the prevention of aspiration into the laryngeal vestibule, since we have observed a number of cases in which the epiglottis has been excised with no resulting postoperative aspiration phenomena, furthermore, in a number of normal cases observed by us, the epiglottic tip has failed to bend backward and downward and has remained erect throughout the second stage of swallowing In these cases, also, there has been no aspiration

After the bolus of fluid passes the laryngopharynx and enters the esophagus the epiglottic tip assumes its erect position, the larynx and cricoid cartilages descend to their resting positions, the aryepiglottic folds straighten out, and the laryngeal aperture is restored to its usual open status so that normal respiration may be resumed Small amounts of residual fluid in the laryngopharyngeal region are easily handled by the two lateral pyriform recess channels between the open aryepiglottic folds and their respective pharyngeal side walls When the next fluid bolus reaches the back of the mouth the entire process is repeated

For a better understanding of the swallowing mechanism it has been found useful to summarize the second stage normal swallowing sequence into the following sub-stages

1 Closure of the center of the laryngeal aperture—brought about by elevation of the cricoid and arytenoid cartilages and pressing of the arytenoid cartilages against the back of the epiglottis

2 Closure of the sides of the laryngeal aperture—brought about by bending and closing of the aryepiglottic folds with the formation of the aryepiglottic fold furrows anterolaterally

3 Passage of the bolus with downward and backward bending of the epiglottic tip

4 Reopening of the laryngeal aperture—effected by the return of the epiglottic tip to its normal erect position and the descent of the cricoid and arytenoid cartilages

We have observed that abnormal aspiration into the tracheobronchial tree occurs by a number of different mechanisms These may be classified as follows.

I *Aspiration Through the Laryngeal Aperture*

- *A* No intrinsic organic abnormality in the laryngopharynx Abnormalities probably of neurogenic origin
  - *1* Faulty timing of the stages with respect to passage of the bolus
  - *2* Inability of the various furrows to close completely and form an effective seal against the leakage of fluid past them
  - *3* Inability of the various furrows to remain closed for the entire period during which the swallowed fluid is passing by
- *B* Organic disease present in laryngopharynx, neoplasms, infiltrations, etc
  - *1* Inability of the folds to close properly and completely because of mechanical obstruction of a mass
  - *2* Inability of folds to close properly because of limited mobility of arytenoids or epiglottic folds due to neoplastic or inflammatory infiltration

3 Inability of folds to close properly because of surgical procedures on the laryngopharynx

II Aspiration Through Abnormal Openings Fistulous Tract Formation These May Occur Anywhere in the Neck or Thorax

These may occur anywhere in the neck or thorax

In the absence of organic disease locally, aspiration is usually the result of functional disturbances and may be of neurogenic origin Faulty timing with respect to the passage of the fluid bolus is commonly encountered As an example, the cricoid and arytenoid may be tardy in rising so that the fluid enters the laryngeal aperture before it can close completely Another similar mechanism is the premature descent of the arytenoids so that the aperture opens before all of the fluid bolus has passed it, with the result that some of the fluid enters the vestibule and is aspirated In other instances the timing may be satisfactory, but the apparently normal ary-epiglottic folds or arytenoids may fail to remain closed and act as an effective seal against the entrance of fluid into the larynx

The second category of cases includes those with bulky neoplasms or infiltrating lesions which block adequate closure of the laryngeal aperture mechanically or inhibit the normal closing actions of the aspiration barrier The presence of these abnormalities is usually apparent clinically and on the preliminary radiographic studies of the neck In this group also belong the cases with aspiration following extirpative surgery other than laryngectomy for various tumors of the supraglottic larynx It has been observed that removal of the epiglottis is often not followed by abnormal aspiration phenomena This is not unexpected, since the closed arytenoid cartilages can still be brought up and pressed against the back of the tongue or residual epiglottic plate to seal off the laryngeal aperture effectively Further investigation of post-operative cases is planned, nevertheless, it is presently believed that preservation of the aryepiglottic folds during surgery is important in preventing aspiration Where these folds are absent or incapable of complete closure, aspiration occurs As yet, no instances have been observed where the true and false cords have been able to act as a satisfactory substitute for the laryngeal aperture components in the prevention of aspiration In all instances thus far, whenever contrast material reached the rima glottidis it went through and entered the trachea, however, further investigation of

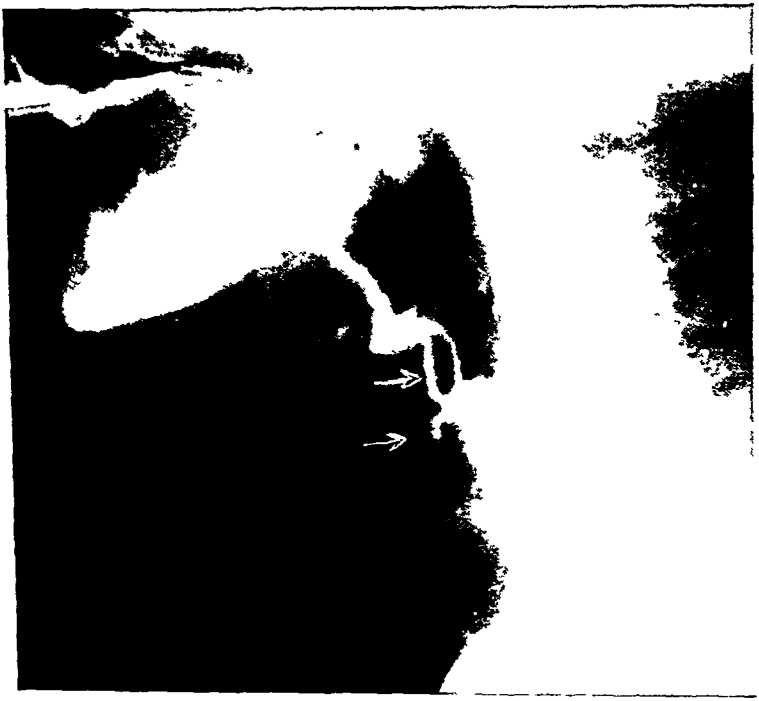

Fig 5-A Case 1 Premature descent of aryepiglottic folds with opening of laryngeal aperture Contrast material spills over the arytenoid cartilages into laryngeal vestibule (lower arrow) Upper arrow at contrast material in pyriform recess trenches

the competency of the glottic elements in preventing aspiration, particularly in the postoperative cases, is being continued

The final group of cases is those in which fistulous tracts exist between the hypopharynx or esophagus and the upper tracheobronchial tree These abnormal connections may occur in the neck or thorax In proving their existence it is necessary to demonstrate the fistula itself and to show that there is no aspiration through the normal laryngeal aperture into the vestibule

Several brief case reports will illustrate a number of the varieties of aspiration phenomena described above

Case 1 Male, aged 72, suffered a cerebrovascular accident, following which he began to aspirate ingested fluids Direct laryngoscopy at the

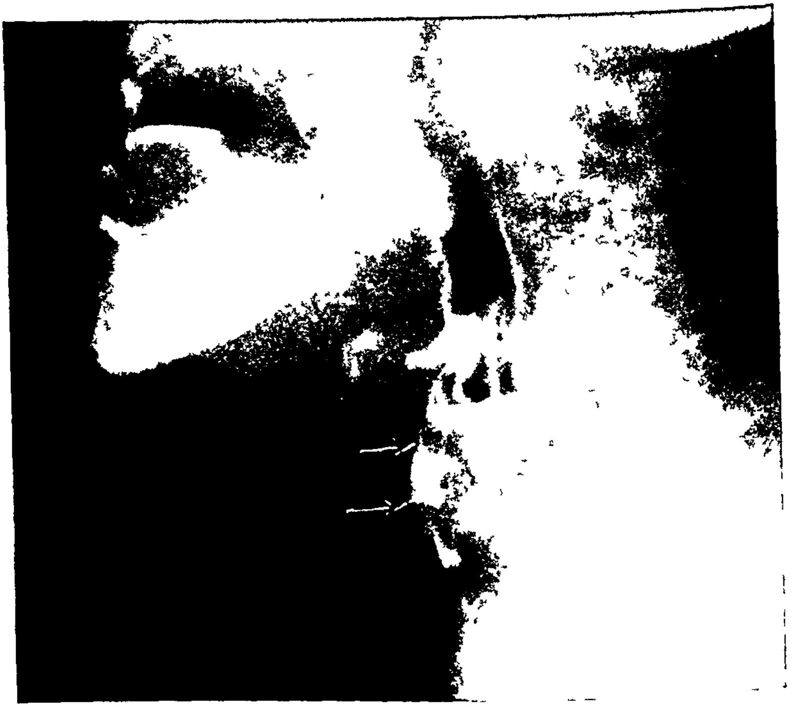

Fig 5-b Contrast material which has entered the laryngeal vestibule (upper arrow) is seen to descend through the rima glottidis (lower arrow) into the trachea

Francis Delafield Hospital revealed no organic abnormality in the hypopharynx or larynx Barium swallow studies with the Fairchild rapid changer demonstrated that the cricoid and arytenoid cartilages rose normally and that there was adequate closure of the laryngeal aperture at the time that the main fluid bolus was passing by, however, the arytenoids and cricoid cartilage descended prematurely before all of the bolus had passed As a result, the laryngeal aperture opened prematurely, and contrast material spilled over the partly descended arytenoids into the laryngeal vestibule and down into the trachea (see Fig 5) This case represents a well defined example of aspiration associated with faulty timing without local organic disease

Case 2 Female aged 54, was admitted to the Francis Delafield Hos pital with a documented carcinoma of the thyroid and extensive metastases in the neck Aspiration phenomena and dysphagia had recently appeared A lateral roentgenogram of the neck revealed marked soft tissue thickening due to the extensive cervical metastases Barium swallow studies with the rapid film changer showed the timing mechanism to be normal throughout the swallowing cycle, however, the aryepiglottic fold furrow did not remain tightly sealed, and contrast material was seen to leak through the incompetent furrow anteriorly as the barium bolus filled the laryngopharynx during the second stage of swallowing The barium leaking through the incompetent furrow entered the vestibule and descended through the glottis into the trachea (see Fig 6) This case, therefore, represents an example of inadequate closure of the laryngeal aperture in one site due to mechanical and/or neurogenic factors associated with extensive neoplastic disease

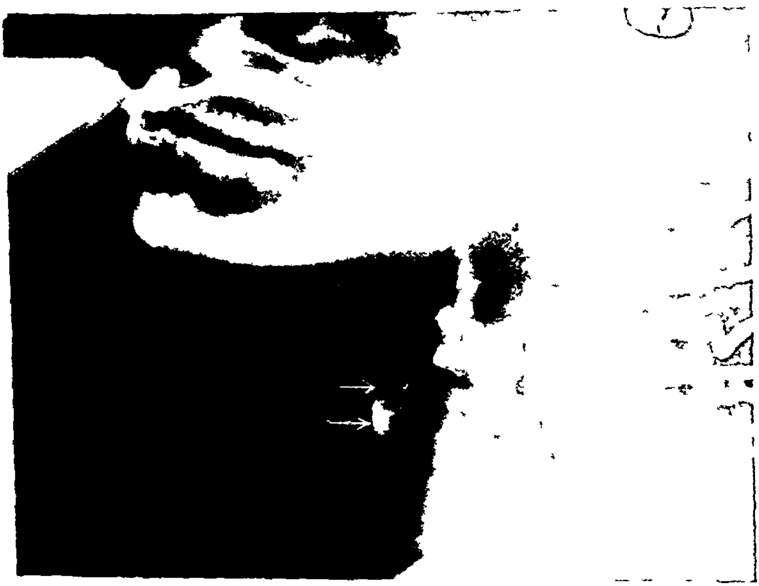

Fig 6 Case 2 Aryepiglottic fold furrow is incompetent anteriorly and contrast material enters laryngeal vestibule just above entricle (upper arrow) Some barium suspension already in trachea (lower arrow)

Case 3 Male aged 62 was admitted with a documented carcinoma of the lung and markedly enlarged lymph nodes in both sides of the neck due to metastases Shortly before admission increasing dysphagia appeared, but there had been no aspiration phenomena Roentgenographic examination of the neck showed the presence of large soft tissue masses due to the metastatic nodes Barium swallow studies revealed marked deformity of the laryngopharynx lumen and deformity of the aryepiglottic fold furrows because of the enlarged cervical nodes, nevertheless the timing of the actions of the laryngopharynx was normal, and the seals remained competent As a result aspiration did not occur (see Fig 7) The dysphagia was due to the huge nodes which distorted and partially obstructed the laryngopharynx there is no aspiration through the normal laryngeal aperture into the vestibule

Several brief case reports will illustrate a number of the varieties of aspiration phenomena described above

Case 1 Male, aged 72, suffered a cerebrovascular accident, following which he began to aspirate ingested fluids Direct laryngoscopy at the Francis Delafield Hospital revealed no organic abnormality in the hypopharynx or larynx Barium swallow studies with the Fairchild rapid changer demonstrated that the cricoid and arytenoid cartilages rose normally and that there was adequate closure of the laryngeal aperture at the time that the main fluid bolus was passing by, however, the arytenoids and cricoid cartilage descended prematurely before all of the bolus had passed As a result, the laryngeal aperture opened prematurely, and contrast material spilled over the partly descended arytenoids into the laryngeal vestibule and down into the trachea (see Fig 5) This case represents a well defined example of aspiration associated with faulty timing without local organic disease

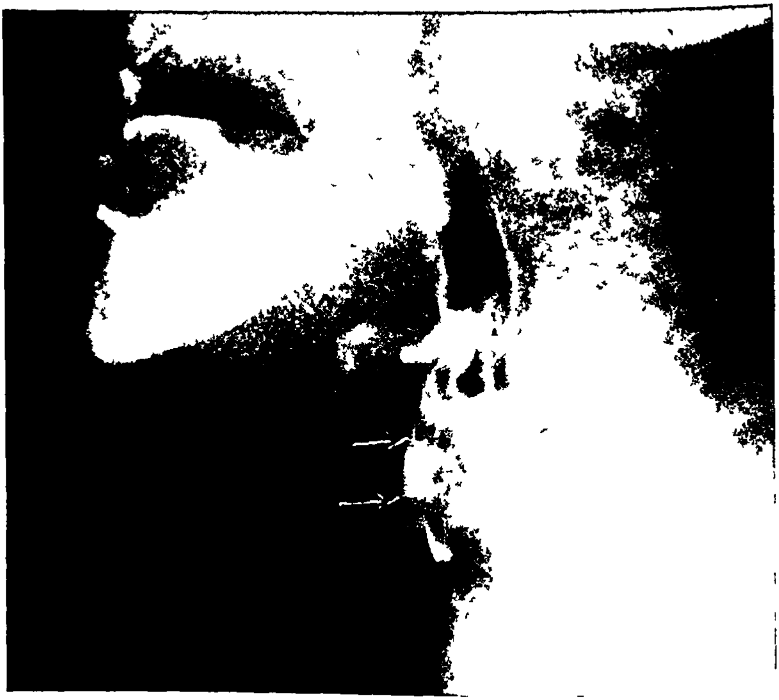

Fig 5-b Contrast material which has entered the laryngeal vestibule (upper arrow) is seen to descend through the rima glottidis (lower arrow) into the trachea

Case 2 Female aged 54, was admitted to the Francis Delafield Hos traction of the cricopharyngeus, presumably to insure prevention of air from entering the esophagus The most marked contraction of the muscle may be seen during a modified Valsalva maneuver, in which expiration is markedly obstructed by complete closure of the nares and almost complete closing of the lips As a result, the cheeks bulge, the hypopharynx becomes distended with air, and the cricopharyngeus goes into marked tonic contraction On the other hand, during swallowing the cricopharyngeus relaxes completely so that ingested material may pass from the hypopharynx into the esophagus without difficulty

Fig 8 Case 4 Larynx completely occluded by huge neoplasm Fistulous tract present between cervical esophagus and trachea near entrance of tracheostomy tube (arrow)

Radiographically, the cricopharyngeus is best demonstrated on the lateral view of the neck after a barium swallow and during the modified Valsalva maneuver described above Sufficient barium residue remains in the hypopharyngeal region to delineate the thickened, contracted muscle bundle The muscle lies immediately below and posterior to the lamina of the cricoid cartilage Its main muscle mass is situated pos-

Case 4 Male, aged 55, was admitted with a huge carcinoma of the larynx which had caused complete obstruction of the airway and previously required tracheostomy Aspiration of ingested fluid had appeared during the past six weeks On roentgenographic examination in the lateral view the huge tumor occluding the larynx and the tracheostomy tube were evident Barium swallow studies showed none of the opaque mixture to enter the occluded larynx, however, a well defined fistulous tract was demonstrated between the upper cervical esophagus and the trachea just above the entrance of the tracheostomy tube (see Fig 8)

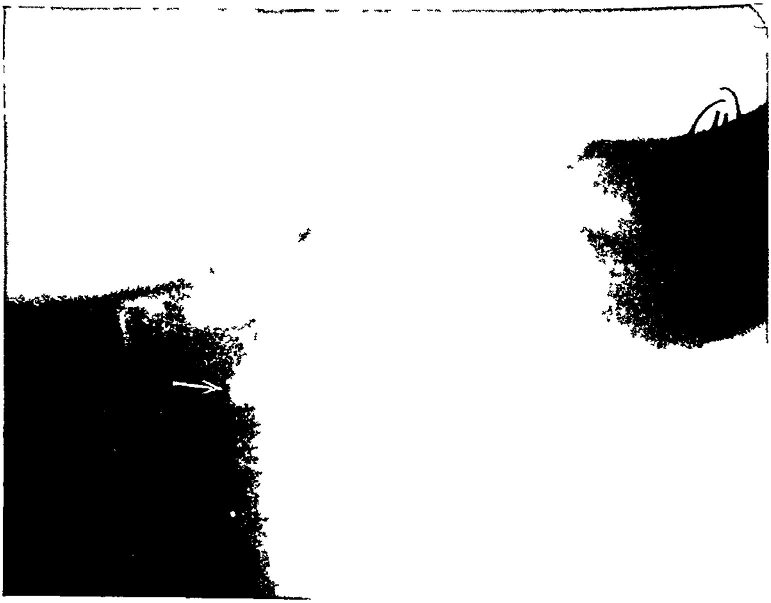

Fig 7 Case 3 Aryepiglottic fold furrow deformed by large neck masses but competent (arrow) No aspiration

DYSPHAGIA DUE TO CRICOPHARYNGEUS SPASM

One of the less common causes of dysphagia is spasm of the cricopharyngeus muscle This muscle represents the lowermost transverse fibers of the inferior constrictor of the pharynx and lies immediately above the pharyngo-esophageal junction The cricopharyngeus acts as a sphincter and normally is in a state of contraction during respiration This closes off the esophagus from the hypopharynx, prevents the swallowing of air and directs the inspired air into the larynx and trachea Our observations indicate that increasing the depth of respirations results in an increased degree of con-remains contracted This interferes with the passage of ingested material from the hypopharynx into the esophagus and causes dysphagia The etiology of the syndrome is obscure No organic abnormalities have been found locally in the hypopharynx, and no associated organic abnormalities have been found elsewhere

We have observed the syndrome in two cases in which recurrent attacks of mild to moderate dysphagia were experienced for several years The condition was not progressive, the attacks did not increase in severity and the patients' general health was not affected There was no weight loss One of the patients was a male, the other a female The former thought that the dysphagia might be related to periods of mental upset The second patient could not definitely relate the recurrence to emotional disturbances

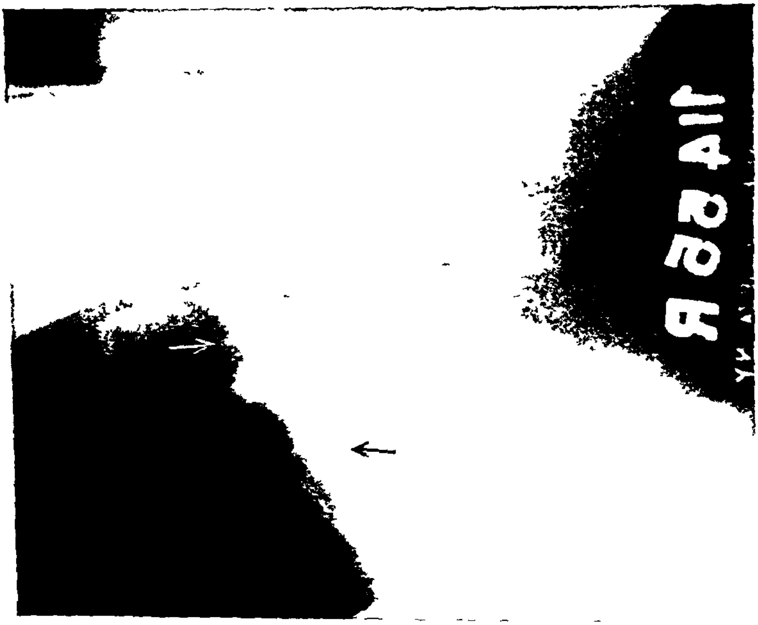

Fig 9-b Normal swallowing Note complete relaxation of cricopharyngeus muscle (lower arrow) and uniform diameter of barium column Incidentally aryepiglottic fold furrow well shown (upper arrow)

terior to the lumen of the inferior end of the hypopharynx and immediately in front of vertebral body C-5 or C-6 When it contracts, a sharply localized, smooth, rounded indentation is seen in the posterior aspect of the barium outlined lower hypopharynx just above the esophagus (see Fig 9-a) No indentation of the anterior wall of the lower hypopharynx due to cricopharyngeus contraction is observed, since there is no significant number of muscle fibers between the lower hypopharynx and the upper trachea in the subglottic region During swallowing the muscle usually relaxes completely, and the barium suspension passes from the hypopharynx into the esophagus with no or only minimal indentation on the barium column in the lower hypopharynx (see Fig 9-b)

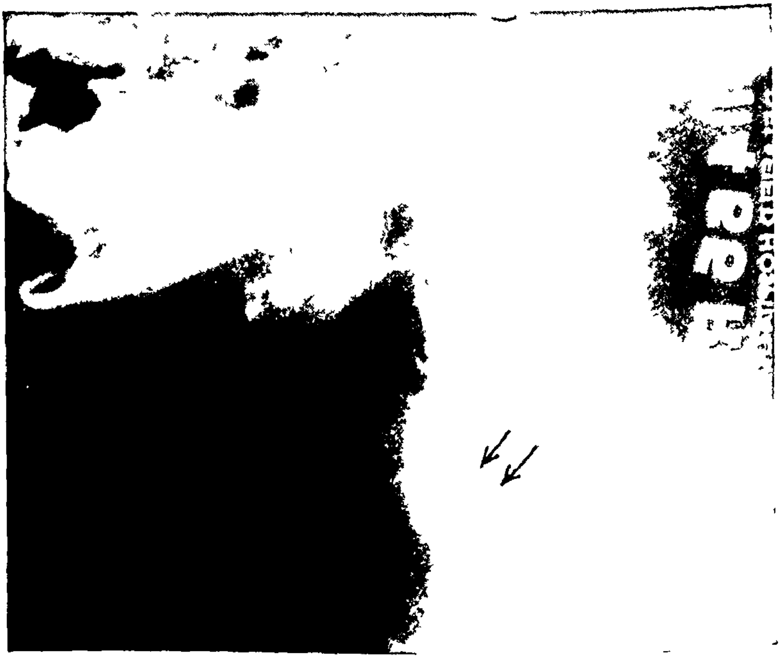

Fig 9-a Contraction of cricopharyngeus muscle during modified Valsalva maneuver Note local forward displacement of barium column by contracted muscle band (arrows)

At times, the cricopharyngeus mechanism is deranged Instead of normal relaxation during swallowing, the muscle

Fig 10) In the frontal views, a short zone of smooth narrowing, about 1 cm in length, was noted between the slightly distended lower border of the hypopharynx and the upper end of the esophagus (see Fig 11) The narrowing appeared due to the constriction of the barium column by the spastic cricopharyngeus

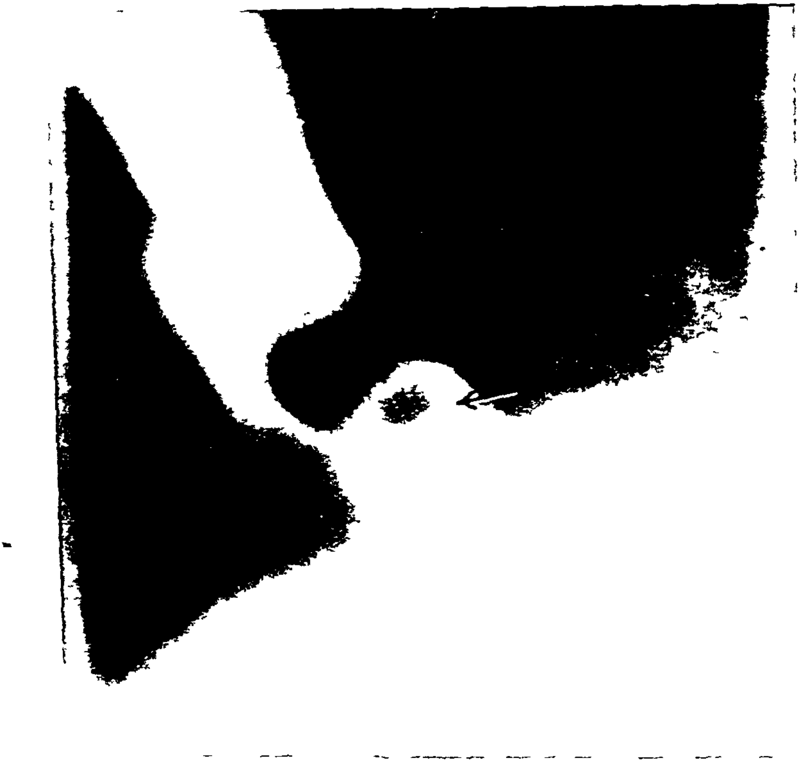

Fig 10-b Cricopharyngeus spasm Smooth indentation of the posterior wall of barium column well shown. Note small collection of trapped air in esophagus just under contracted muscle (arrow)

Cricopharyngeus spasm is to be differentiated from neoplasms of the hypopharynx and other masses in the neck. In tumors of the posterior wall of the hypopharynx, the swelling and indentation are usually not restricted to the cricopharyngeus region The width of the *prevertebral space* is thickened to various degrees, and the posterior wall of the

The radiographic appearances of both cases were very similar In the lateral views, made with the rapid changer during barium swallows, each case showed a sharply localized, marked, smooth indentation on the posterior aspect of the barium-filled hypopharynx in the region of the cricopharyngeus muscle The laryngo-pharynx cephalad to the indentation was slightly distended, but otherwise normal The margins of the barium-filled pharynx were smooth and straight throughout, except at the cricopharyngeus site No other soft tissue swelling was observed elsewhere, and there was no mucosal irregularity or ulceration The anterior margins of the hypopharynx showed no abnormal indentations (see

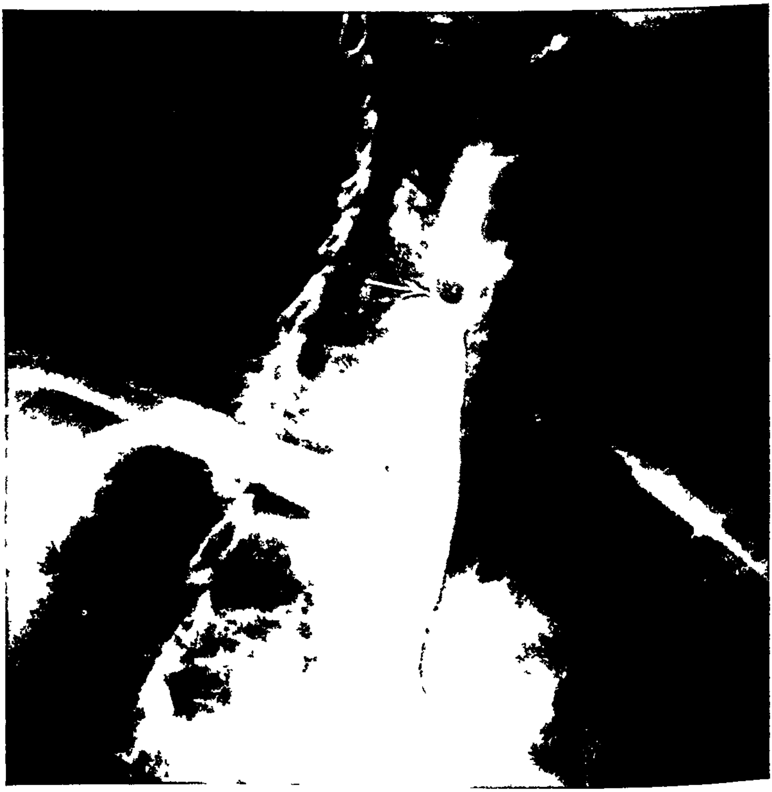

Fig 10-a Cricopharyngeus spasm Note smooth indentation (arrow) on posterior aspect of barium column by contrasted muscle

2 The value of a 9x9 inch film rapid changer permitting exposures up to a rate of two per second is demonstrated

3 The mechanism of prevention of aspiration during swallowing is discussed

4 A classification of abnormal mechanisms resulting in aspiration is presented

5 Illustrative case reports are briefly presented

6 The anatomy and action of the cricopharyngeus muscle during respiration and swallowing are discussed

7 The radiographic appearance of cricopharyngeus spasm is described and its differential diagnosis from tumors of the hypopharynx and other portions of the neck detailed

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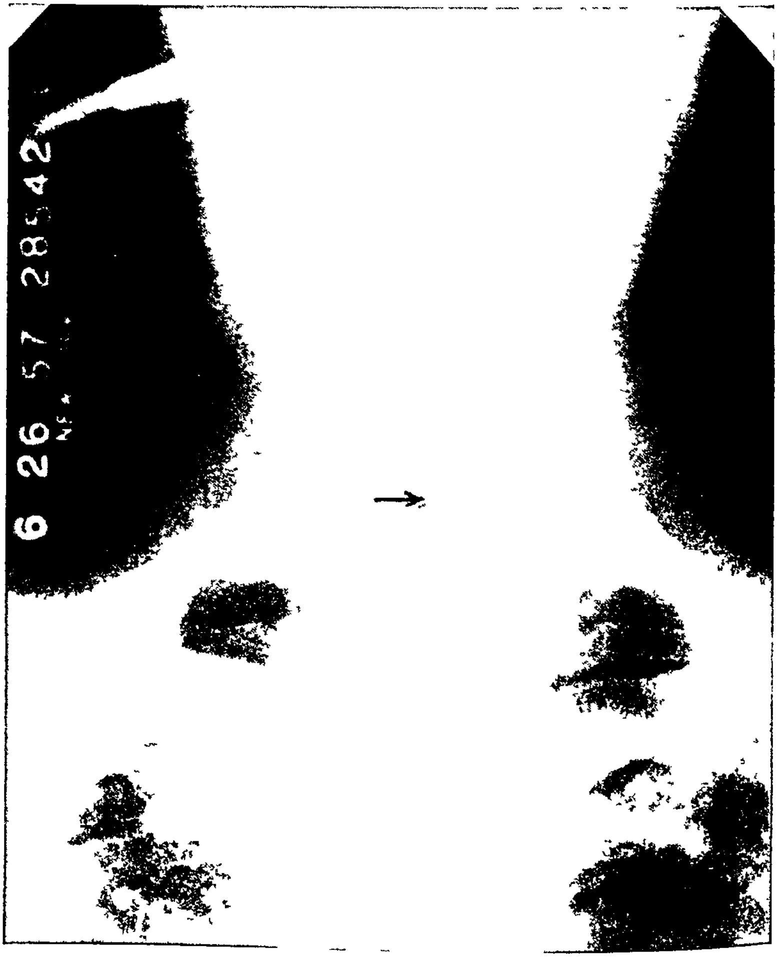

Fig 11 Cricopharyngeus spasm Frontal view Note narrowed segment of barium column (arrow) between hypopharynx and cervical esophagus due to constriction by the spastic cricopharyngeus

barium filled hypopharynx appears somewhate sinuous, due to the multiple indentations of the growing tumor In other cases, there are indentations on the lateral and anterior surfaces of the hypopharynx by neoplasms situated in these areas

SUMMARY

1 The anatomy and physiology of the laryngopharynx are described in detail during the second stage of swallowing

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JUVENILE NASOPHARYNGEAL ANGIOFIBROMA

A Theory of Pathogenesis[*][†][‡]

MAURICE SCHIFF, M D ,

Oakland, Calif

HISTORICAL

Historically, juvenile angiofibroma was probably included in the early descriptions of nasal polyps, as described by Hippocrates[1] in the Fourth Century, B C , and by the Eighteenth Century was recognized by the individual characterization distinguishing hard, fibrous polyps from soft, mucous polyps Probably the earliest description of this tumor, which "commonly occurs in persons about the time of puberty," was by Chelius[2] in 1847 Much was written in the early Nineteenth Century describing the various facial deformities caused by large nasal polyps, and the operations to remove these bulky tumors The sex selectivity of the angiofibroma was practically unobserved except for a few isolated clinicians such as Legouest,[3] who in 1865 noted the predilection for these tumors in males, and Gosselin[4] who in 1876 observed the tendency for spontaneous regression after sexual maturity About the same time (1878) Bensch,[5] in Germany, published the first comprehensive report on this nasal tumor , however,

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[*] Presented as Candidate s Thesis to the American Laryngological Rhinological and Otological Society 1959 and read at the Sixty-Second Annual Meeting Hot Springs Va March 12 1959

[†] Captain Medical Corps United States Navy Chief Eye Ear Nose and Throat Service United States Naval Hospital Oakland Calif The opinions or assertions contained herein are the private ones of the author and are not to be construed *as official* or necessarily as reflecting the views of the Medical Department of the Navy or of the Naval Service at large

[‡] Recipient of the Harris P Mosher Award 1959

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Infection, nasal allergy, heredity, trauma, or ethnic origin did not appear to be etiologic factors Their only observation was that over half of the cases appeared to have underdevelopment of secondary sex characteristics In the review of the subject by Hughes,[13] it was thought that anatomic, craniopharyngeal duct inclusion might be a factor in the etiology of this tumor

Spielberg[14] suggested that chronic suppurative posterior sinusitis may be a contributing factor in the etiology of juvenile nasopharyngeal angiofibroma, and made a plea for better examination in sinusitis with polyps Som and Neffson[15] believed that there is an inequality of the development of the bones of the skull so that the periosteum is unable to produce typical bone, and, with increased endocrine growth stimulus during puberty, hypertrophy occurs in place of bone formation They suggested that spontaneous regression occurs when ossification is complete This regression has been proposed by others, such as Persky[16] and Milligan,[17] to occur because, with the closure of suture lines by ossification, the growth stimulus and blood supply to the tumor are diminished

THEORY OF PATHOGENESIS

Since Koch's postulates are not applicable in tumors and since the nasopharyngeal fibroma has never been successfully induced in an animal experimentally, it is necessary to evolve a theory, or *modus operandi*, when dealing with this mesenchymal tumor This theory is predicated upon inductive and deductive types of reasoning based on previous experimental data applied and interpreted by the author in the light of clinical experience and microscopic study of four cases of juvenile nasopharyngeal fibroma It is believed that this tumor is due to an alteration in the pituitary androgen-estrogen axis, most probably involving overactivity of the pituitary and reflecting itself in a ground substance response to a vascular tumor This conclusion is reached after a careful study of the literature and the author's cases, with microscopic evidence to show the response of the tumor before and after treatment

Chaveau[6] in 1906 was the first to suggest the term "juvenile angiofibroma."

The surgical removal of these tumors was attempted as early as the Second Century, A.D., by the cultured Roman physician, Celsus, who in his compendium to surgery described removal by digital or wire snare, and tearing off of tumors with forceps. Hot iron cautery and injection of escharotics were attempted in later centuries. Langenbeck[7] in 1834, advocated one of the first definitive approaches to the nose and nasopharynx. Modifications of this are still used at the present time. In the latter part of the Nineteenth Century, tracheotomies and ligation of both external carotid arteries were mentioned as preliminary steps before the definitive sanguineous nasopharyngeal surgery. Senn published a volume in 1900, quoting the works of Ollier and Rogue,[8] wherein descriptions of different approaches to the nasopharynx were presented. Some of these have been recently rediscovered.

HISTOGENESIS AND THEORIES OF ORIGIN

The most widely accepted theory of origin of the nasopharyngeal fibroma is that the tumor is derived from embryologic chondrocartilage during the development of the cranial bones. The basiocciput is joined to the body of the sphenoid by embryonal cartilage. The ossification of this cartilage occurs in the second decade of life. It is from the perichondrium lining this and other postnasal spaces, according to Bensch and Ewing,[9] from which this tumor is thought to originate. New and Kirch[10] do not agree with this viewpoint, since it does not explain the position and location of the tumor on that basis. They quoted Coener's theory of the tumor being one of bone in which the chondrocranium would be the matrix of the tumor. In this way, the various positions, the character, and the spontaneous involution could be better explained.

Figi and Davis[11] suggested that acute inflammation and trauma may be exciting or accelerating factors. Martin, Ehrlich, and Abels[12] in their excellent presentation of this subject were unable to find any systemic disease as a causative factor

Infection, nasal allergy, heredity, trauma, or ethnic origin did not appear to be etiologic factors Their only observation was that over half of the cases appeared to have underdevelopment of secondary sex characteristics In the review of the subject by Hughes,[13] it was thought that anatomic, craniopharyngeal duct inclusion might be a factor in the etiology of this tumor

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An attempt will be made to satisfy the following obvious characteristics of the tumor which in previous explanations and theories have led to highly controversial opinions

1 The fibrous nature of this tumor.

2 The angiomatous component of this tumor

3 The sex predilection for males

4 Its exclusive location in the nasopharynx

1 FIBROUS NATURE OF THE TUMOR

a *Connective Tissue Component*

In discussing the fibrous nature of this tumor, it is necessary to discuss the connective tissue and ground substance of the body in general In 1933, Klinge[15] conceived that the connective tissue of the body could respond as an organ to disease Klemperer[10] classified a large number of conditions as diseases of connective tissue Until then, the extracellular compartment was not considered as an organ either in morphology or function, however, with the advent of a unified concept of collagen disease, and especially since the study of Cortisone, we have begun to consider the ground substance as an organ The anatomy of this *milieu interieur*, as Claude Bernard described this space, is composed of cells—mainly fibroblasts, mast cells, lymphocytes, plasma cells, and undifferentiated mesenchymal cells The connective tissue fibers are collagen, elastica, and reticulin, of which the first is the most important in our thesis The other important component for this discussion is the amorphous ground substance, consisting of mucopolysaccharides and glycoproteins in varying degrees of polymerization Ordinarily it has a gel-like consistency and is not very water-soluble, however, under certain abnormal conditions, it may become depolymerized, more fluid and finally, water-soluble

The physiology of the extracellular compartment may be altered by many conditions This is important, since this space represents the internal environment of the cells and, therefore, many of the protective reactions and defense mechanisms aimed at maintaining the homeostasis of the cell, occur in this area The effect of infection (such as gangrene and streptococci) has been known to spread through tissues with great rapidity Duran-Reynals[20] pioneered in showing that this spreading factor was due to hyaluronidase acting on the hyaluronates of the ground substance Some poisonous snakes and insects excrete a spreading factor of a similar nature, which explains the rapid spread of tumefaction following their injection or bite

Certain neoplasms also have the ability to increase the amount of ground substance and fibrous reaction to a given tumor Antihyaluronidase has been found in animals and human subjects bearing these tumors This desmoplastic diathesis or fibrous tissue reaction to tumors has been magnificently presented by Pack and Ariel[21] in their study on this subject

Metabolically, the tissues of the extracellular compartment have no blood supply of their own and they must depend upon chemicals, usually enzymes, as proper food for maintenance and growth, thus, deficiencies of Vitamin C, an anaerobic oxidative substance, markedly reduces the ability for healing and fibroblastic proliferation Pyridoxine deficiencies cause increase in the metachromasia of the ground substance Hypoproteinemia causes an osmotic change in the ground substance which also retards wound healing

The spreading factor of the enzyme hyaluronidase is inhibited by many of our commonly used medications, such as epinephrine, morphine, antihistamine, salycilates, and rutin It is probable that at least part of the beneficial effect of the therapy to the patient is on this basis

The hormonal effects on connective tissue have been observed empirically for many years Their relationship to the more intimate details of ground substance reaction was more extensively discussed at the Fifth Connective Tissue Conference in 1954[22] In brief, the following hormonal effects are noted and are intimately related to the author's thesis Estrogen decreases the permeability of the ground substances, gonadotropic hormones increase its permeability, desoxycorticosterone enhances the deposition of collagen and fibroblastic proliferation, and the excretion of testosterone and estradiol characteristics of the tumor which in previous explanations and theories have led to highly controversial opinions

1 The fibrous nature of this tumor

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1 FIBROUS NATURE OF THE TUMOR

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The physiology of the extracellular compartment may be altered by many conditions This is important, since this space represents the internal environment of the cells and, therefore, many of the protective reactions and defense mechanisms aimed at maintaining the homeostasis of the cell, occur in this area The effect of infection (such as gangrene better studied. It is impossible within the scope of any single work to cover the tremendous amount of basic and voluminous investigations which have been accumulated in the past 15 years, particularly since the studies of the action of corticosteroids. Discussion will be limited to those facts which are pertinent to this thesis. Persson,[26] in discussing the multiple functions of the ground substance, postulated that it is an end organ for many hormones, including adrenocortical, sex, and thyroid. Figs. 1 and 2 would seem to substantiate this contention.

In studying the distribution of mucopolysaccharides by chemical methods in connective tissue, five were identified.[27]

1. Hyaluronic acid.
2. Chondroitin sulfate A.
3. Chondroitin sulfate B.
4. Chondroitin sulfate C.
5. Hyaluronosulfate.

It appears that the quantitative difference of each of these components, together with the degree of polymerization, determines to a great extent what the mesenchymal tissue is to be. Whether it will be vitreous humor, synovial fluid, hyaline cartilage, aorta, or skin can be demonstrated histochemically. It would suggest from the various studies on connective tissue makeup that, depending upon the character and type of stimulus, the chemical nature would be altered, and one of these forms might be changed into another. There is ample evidence to indicate that this might occur. Upon study, it would appear that the case reported by Wirth and Shimkin[28] actually could have started out as a juvenile angiofibroma and become a chondrosarcoma, despite the fact that this might be an extremely rare occurrence. Cartilage has been shown to develop from the periosteum of membrane bone by Pasternack, Lillie and Jones,[29] and extraskeletally by Binkley and Stewart.[30] The latter authors, in their excellent discussion, have stressed the concept of metaplasia of connective tissue into bone under some unknown influence. They also believed that one of the conditions for ossification and calcification is inhibits these reactions The sex skin of the monkeys demonstrated the changes of the ground substances under the normal hormonal cyclic control [20,21,23,24]

The preceding and following observations on endocrine connective tissue responses are being assembled and presented to substantiate the author's contention that there are ample experimental data to explain the microscopically-observed connective tissue alterations in response to estrogen therapy (see Figs 1, 2, 3, 4) Geschickter and Lewis[25] reported several interesting observations on tumors of these tissues They also agreed that the basal fibroma probably originates from the periosteum of the chondrocranium in the region of the basiocciput They were able to induce an increase in the maturity and amount of connective tissue in the breast and uterus of monkeys by the injection of estrin They were also able to produce similar changes with anterior pituitary gonadotropic hormone only if the gonads were present

This author has commented to the pathologist on several occasions on the similarity between young keloid and angiofibroma This was more extensively studied[25] when hormone assays were made of a huge keloid of the ear In this case, the bio-assay of the keloid revealed 13,000 rat units of gonadotropic hormone and 3,500 rat units of estrin The keloid, like other desmoid tumors related to sex, may become arrested or regress when the hormone state is altered The conclusion of these investigators[25] is worth noting "The results would seem to indicate that tumors of connective tissues have the power to hold or concentrate both anterior pituitary gonadotropic and estrogenic substances These hormones are not merely stored in the tissue, but also have a direct influence on the growth of the tissue where they are found, as confirmed by experimentation "

In general, the connective tissue makeup is essentially similar, being mucopolysaccharide and glycoprotein in nature Histochemically, it is made up of protein fibers of several specific types embedded in a mucous ground substance The protein fibers are of three main types *1* elastica, *2* collagen, and *3* reticulin The mucopolysaccharides have been more extensively investigated and the histochemical characteristics stain is nonspecific and stains a large group of substances including glycogens, polysaccharides, glycoproteins, and many others Its stain depends upon the free aldehyde group so that when treated all polymers, both large and small, are stained with this dye substance (see Figs 11, 12, 13, 14, 15, 16) The colloidal iron stain shows the blue staining ground substance which is also depolymerized by hyaluronidase incubation (see Figs 17, 18, 19, 20, 21, 22) All histochemical microscopic slides used in this thesis were made by the controlled simultaneous preparation method of Weisskopf and Burn,[33] so that as far as possible, changes in the staining characteristics are histochemical, not artifacts

3 Connective tissue may be formed by the action of the primitive fibroblasts on the substrate of the ground substance Histochemical data suggest that this cell is especially related to the fibrous elements of the connective tissue while the mast cells, which also make heparin, reflect or produce changes in the ground substance

4 Recently, Curran[34] published his findings which show that the capillary endothelium has the capacity to elaborate mucopolysaccharides Activity of this function of the endothelium is increased in tissue repair, tumor stroma, and osteogenesis It synthesizes sulfated mucopolysaccharides and is concerned functionally with anticoagulation, transfer of nutrients from the blood, and the making of new ground substance

b Connective Tissue Stain

The significance of the histochemical changes observed in the study of these various staining techniques is still controversial, however, one has only to look at the amount of information obtained from the routine hemotoxylin and eosin stain to see that many substances are either not stained at all or fail to show any contrast in the components of their supporting structure The Schiff stain (PAS) demonstrates this well in the intense pink perivascular staining about young blood vessels This might give some support to the work of Curran[34] showing the intimate relationship between the endothelium and the production of mucopolysaccharides a circulatory one caused by *a* hyaline obliteration of capillaries, *b* development of cavernous vessels favoring stasis and probable anoxemia or hypoxia This latter condition probably exists in a juvenile angiofibroma since measurements have never been actually made of blood flow rates through the tumor Despite the fact that clinically, when cut, it bleeds so frightfully, stasis still may be present This bleeding is believed to be due to the large number of transsected, small vascular spaces whose cross sectional sum total would equal the size of almost any vessel in the body with the exception of the aorta, also, the lack of a muscular coat about these vessels prevents them from closing off Pressman,[31] in a series of photomicrographs of the aorta grafted on to the trachea, showed that the cartilage was eventually replaced by bone from changes in its connective tissue stroma This appeared to be due to ischemia or stasis changes and could be reproduced regularly in the animals Clinically, the juvenile angiofibroma always appears to have considerable congestion The degree of chronic congestion may be another factor which determines the variable density of the collagen found in this tumor It seems obvious that in some manner the vascular component must exert a profound influence on the connective tissue component

The source of the mucopolysaccharides, which make up the ground substance, has been highly controversial and exciting

1 For many years it was assumed that the fibroblast itself was the direct source of connective tissue

2 Asboe-Hasen[32] found a correlation between the number of mast cells and the quantity of hyaluronic acid in tissues The presence of numerous mast cells can be seen, particularly in a toluidine blue stained photomicrograph As seen in Figs 5, 6, 7, 8, 9, and 10, the metachromasia is dependent upon high polymer hyaluronic acid and the pink-violet is considerably depleted when treated with the enzyme hyaluronidase This enzyme may be of streptococcal source (which is more specific for hyaluronic acid), or it may be from the testicular source which is more diversified in its depolymerization of mucopolysaccharides The latter type (Wydase) was selected because of the ease of availability Schiff's periodic acid stain is nonspecific and stains a large group of substances including glycogens, polysaccharides, glycoproteins, and many others Its stain depends upon the free aldehyde group so that when treated all polymers, both large and small, are stained with this dye substance (see Figs 11, 12, 13, 14, 15, 16) The colloidal iron stain shows the blue staining ground substance which is also depolymerized by hyaluronidase incubation (see Figs 17, 18, 19, 20, 21, 22) All histochemical microscopic slides used in this thesis were made by the controlled simultaneous preparation method of Weisskopf and Burn,[33] so that as far as possible, changes in the staining characteristics are histochemical, not artifacts

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The colloidal iron stain depends upon the affinity of the mucopolysaccharides for colloidal iron and is demonstrated as an intense blue coloring, particularly about the blood vessels The collagen has a red-brown color A study of sections with this stain certainly indicates the abundance of material never shown to exist in routine H & E stains

The toluidine blue stain demonstrates mucopolysaccharides in the ground substance and the large number of mast cells This would be in keeping with the observations of Asboe-Hansen[2, 32] as to the function and contribution of the mast cells to connective tissue

All of the above histochemical studies for ground substance are influenced by the presence of hyaluronidase This enzyme breaks the bonds in the large polymers of hyaluronic acid The result is a depolymerization and loss of staining characteristic in the toluidine blue and colloidal iron preparations Since PAS depends upon the aldehyde linkage, the effect of hyaluronidase is minimal in that it only breaks the large polymers into smaller ones which still have an available aldehyde group when stained This is observed in the slight change in staining characteristic following treatment of the tissue with hyaluronidase

A more complete discussion and further references on the technical aspects of the stains are presented by Weiskopf and Burn[33]

The question arises Is this a major source of ground substance, and to what extent is it controlled by the endocrine system of the body? The problems to be solved about basic studies of the ground substance and connective tissues of the body are innumerable, but with each added fact, enlightenment becomes greater, and the knowledge regarding juvenile angiofibroma is augmented since it is intimately related to progress in this field of investigation

2 ANGIOMATOUS COMPONENT OF THE TUMOR

It is difficult to separate the fibrous from the vascular nature of this tumor, but perhaps better understanding of its character can be obtained if an attempt is made to analyze each component separately. While studying the endocrine aspect of the vascular component, it becomes apparent that much of this work was done on atrophic rhinitis. Since many of the aspects of this condition are in the diametrically opposite end of the fibrovascular spectrum and therefore, are produced by a dysfunction of the pituitary endocrine action opposite to that theorized to exist in juvenile nasopharyngeal angiofibroma, a simultaneous study of both of these conditions can be productive.

Soskin and Bernheimer,[35] while studying and observing the mechanism of estrogenic effect on the nasal mucosa in atrophic rhinitis, noted a specific proliferative effect of estrin. This produced a secondary hyperemia which they concluded was due to the acetylcholine-like action of estrin. Reynolds[36] and Fagin and Reynolds,[37] in their studies on the effect of estrin on the animal uterus, observed vascular alteration. In general, they measured a considerable decrease in the number of vessels per square millimeter in the treated over the untreated uterus. These observations are confirmed by the findings shown of the estrogenic effect on juvenile angiofibroma as demonstrated in Figs. 3 and 4. Mortimer, Wright, and Collip[38] made a significant contribution in their excellent paper dealing with atrophic rhinitis. They performed cranial skiagrams or X-rays in 68 cases of ozena. A large majority showed a dyspituitary state during or subsequent to the growth period. Speculation on the mode by which a dyspituitary constitution might influence the morphologically specialized conchal mucosa, led these investigators to study the nasogenital relationship of monkeys. They recognized the fact that the administration of estrogenic substances produced a specific response in the turbinate mucosa similar to that resulting in other sex skin areas. They concluded that atrophic rhinitis may be genetically transmitted in special familial constitutions in which anterior pituitary lobe function is unstable in secretory activity, nature, or time of activity. A very important piece of work corroborating the influence of sex hormones on the vascular system was written by Edwards, et al.,[39] on their studies of cutaneous vascular and pigmentary changes in castrate eunuchoid men. The observed cutaneous areas showed large venous beds with dilated capillaries. This condition could be reversed by giving the castrate testosterone propionate The excitability of the cutaneous blood vessels could be increased by the use of estradiol and decreased by testosterone This study is particularly interesting when one reflects on the observations of Martin, Ehrlich, and Abels[12] discussing the underdevelopment of secondary sex characteristics in over one-half of their case reports concerning angiofibromas The discussion about the action of estrogen and androgen on the blood vessels of the body is by no means entirely a nebulous theoretical concept Koch, Escher, and Lewis[40] used estrogenic hormone in treating hereditary hemorrhagic telangiectasis of the nose in five cases, with excellent results Fortunately, they were able to measure the urinary gonadotropin and follicle-stimulating hormone, and found these values to be high Conversely, the measurement of the estrogen level, made simultaneously during the period of hemorrhage, was low Treatment with ethinyl estradiol resulted in the suppression of the pituitary, and within one week an actual change in the mucous membrane was observed The color became pink, and the crust and edema of the membrane disappeared In the three females and two males on whom this treatment was employed, the telangiectasia decreased and disappeared in some of the patients The disappearance of the edema strongly suggests a change in the ground substance as well, and marked involution of the blood vessels suggests the pituitary suppression and local estrogen activity, much in the same manner as is being hypothecated by the author in juvenile angiofibroma In general, it is the purpose, therefore, to present in this section the accumulated data to confirm and support the contention that the various hormonal components have a specific effect upon the blood vessels of the body, each having its own characteristic response The mechanism for these specific responses is not entirely understood as yet

3 SEX PREDILECTION FOR MALES

The reason for the predilection of this tumor for the male seems to be for the most part, almost self-explanatory in the light of the findings noted in the previous section on the endocrine nature of its angiomatous component In brief, the human body contains both estrogenic and androgenic substances In the preadolescent male, as he commences to enter adolescence, there is a hypoandrogenic state with its characteristic basal vascular bed The pituitary may be normally active, or relatively hyperactive in that the threshold for gonadal response or balance may be so altered that growth stimulus continues despite the lag in the production of androgen This growth stimulus from the pituitary under certain conditions has the capacity to produce fibrous tumors This is best demonstrated in acromegaly, the extreme of pituitary somatotropic hypersecretion The incidence of tumors in these cases is much higher than normal, most of them being fibromas of the skin Here all mesenchymal tissues are stimulated to grow, which accounts for the thick coarse skin of the acromegalic who has a tendency to form keloids both with and without trauma The basic effect in these cases is in the ground substance which is plentiful and shows intense metachromasia and numerous mast cells and fibroblasts The bundles of collagen fibers are thick and coarse These findings have been frequently noted by Asboe-Hansen,[41 43] who has contributed monumentally to the knowledge of connective tissue in health and disease

The present method for measuring slight subclinical deficiencies or overactivity of any part of the endocrine system is crude at best Only when profound pathologic changes are found is it possible to give the disease a name and measure the gross disturbance of secretions Precise blood values for the male and female sex hormones of the normal individual have yet to be determined

Whenever the feature of sexual dimorphism occurs in any disease entity, it provokes considerable speculation as to its cause Recently, Rauch[43] noted the hormonal dysfunction in those cases of laryngeal carcinoma developing in women and classified them in groups One series showed slight androgenous hair distribution, atrophic breasts, deepening voice changes, and vascular anomalies of the terminal vessels Here, again, this observation of the effects of sex hormones on tumors and blood vessels was noted He presented a highly involved neuro-endocrine basis for the development of these tumors Despite its complexity his interesting thesis appears to be in the right direction to permit greater understanding of basic pathologic processes of tumor formation It is apparent that if estrogens have the ability to inhibit hypervascularity, in contrast to peripheral vasodilatation caused by its acetylcholine effect, and can also decrease the permeability of the ground substance, then, juvenile angiofibromas, by their very nature of genesis, would be discouraged in the female This is an obvious clinical truism Upon this basis, since the tumor does not exist in the female (except very rarely), if we could convert a patient with this tumor into a female type it might cause the tumor to involute These speculations have borne fruit, at least in the limited number of cases tried in the present series

4 EXCLUSIVE LOCATION IN THE NASOPHARYNX

The exclusive location of this tumor in the nasopharynx requires an evaluation of what factors or what tissues function in the nose particularly, but not generally in the rest of the body That the nose is a sexual organ has been recognized for many centuries as far back as Hippocrates and Celsus One has only to think phylogenetically of the function of the nose in all other mammals to realize that it is *via* this organ that most animals find their mates and their food At that level of life, the nose is necessary for survival and procreation The observed alteration of the nasal mucosa during menstruation is generally credited to Briesgen[44] in 1881, who noted and studied this phenomenon The further endocrine implications were studied clinically in relationship to pregnancies, sexual excitement, as well as menstruation, by such early writers as MacKenzie,[45] Endriss,[46] and Fliess [47] In 1912, Sieffert[48] integrated much of the previous data, and recently Mohun[49] brought these data up to date and concluded that the change in the nose depended to a large extent on the ovarian hormones in women Mortimer, Wright, and Collip,[50] in their outstanding study of the endocrine effect on the nasal mucosa of monkeys, clearly showed the nasogenital relationship In these animals, if the turbinates were excised, the testes did not descend This response was most profound when the middle and inferior turbinates were removed The nasal mucosa reacts to estrone synchronously with a change of nipple and sex skin The response of the turbinate in the intact, endocrinely balanced, normal animal is specific, showing redness and swelling This specific response can be produced with estrone in a castrate female but it cannot be produced in the similarly prepared castrate animal by using pituitary gonadotropin This would indicate that a local effect was necessary The recognition of the local effect suggested its use by these investigators[50] for atrophic rhinitis Pseudopregnancy in rats has been induced by the application of silver nitrate to the nasal mucosa, by Rosen and Shelesnyak[51] This, again, emphasizes the nasogenital relationship since nasal stimulation is able to elicit an ovarian response and diestral prolongation

After reading the above findings, one might be tempted to ask how it is possible that estrogens produce one effect in one patient or animal and a different effect in another To communicate this explanation, one may revert to a dynamic German philosophic term, "the *Gestalt*" This is a configurational pattern for that moment which is under a constant change with every change of data Thus, the configuration of the total endocrine pattern in any one patient is almost totally unknown except for the measured amount administered or which may be measured by the present available gross methods The further proof that this incomplete knowledge is recognized is that the laboratory values are practically never at a set figure but instead, a range for the "normal", therefore, each individual response in the disease state depends to a great extent on the *Gestalt* and on the myriad of unknowns influencing the *milieu interieu* as well as the general environment This should explain to some extent the diversity of responses to any endocrine therapy and serve to stimulate efforts to decrease the myriad of unknown factors

Since the vascular makeup of the inferior turbinate is hormonally sensitive, it does not seem difficult to conceive that in the developmental stage of the nasopharynx a small nidus of similar vascular tissue might have been caught up in the large sheet of mesenchyma developing into the periosteum The basiocciput, the basisphenoid, and ethmoid are all of similar chondrocranial origin We have many other parallels to this ectopic location of tissue in embryology, particularly of the same germ layer That the angiomatous component might be the most important has been suggested by Martin, Ehrlich, and Abels[12] The fibrous response is probably desmoplastic in nature, provoked by the local ectopic vascular tumor and the general endocrine response to it of the ground substance of the body It is well nigh impossible to prove the speculation that these tumors arise as responses to ectopic vascular tissue, since no one has ever reported the observation of a juvenile angiofibroma developing from its incipiency Usually when first seen, they are already of moderate size Nonetheless, it seems logical that here we have sex-hormone sensitive vascular tissue in the inferior turbinate, and as long as this tissue is in its proper location, the body response is normal, not desmoplastic If, however, a small portion of vascular tissue of the inferior turbinate type were to be found in the periosteum in the developmental stage, there would be adequate reason for the mesenchyma of the periosteal layer to provoke an attempt to wall off this ectopic tumor with connective tissue, its only potential for response The response would not begin until the sensitizing hormones start to circulate in puberty

CLINICAL COURSE

The juvenile angiofibroma is a benign expanding entity, often somewhat encapsulated and noninfiltrating, which originates in the posterior nares or nasopharynx It is composed of mixed angiomatous and fibrous tissues occurring almost solely in adolescent males, with a tendency to involute spontaneously upon full sexual maturity

The phrase, "tendency to spontaneous involution," as used in contrast to the general comment in the literature, is based upon the author's personal experience with four cases of active, young, healthy males—all in the second decade of life This is supported by the more voluminous experience of Figi and Davis[11] in which they stated, "We never observe the complete spontaneous disappearance of these fibromas that is often referred to in the literature"

In the outstanding report by Martin, Ehrlich and Abels,[12]

PRESENTATION OF JUVENILE ANGIO-FIBROMA WITH PHOTOGRAPHS OF THE NASOPHARYNX

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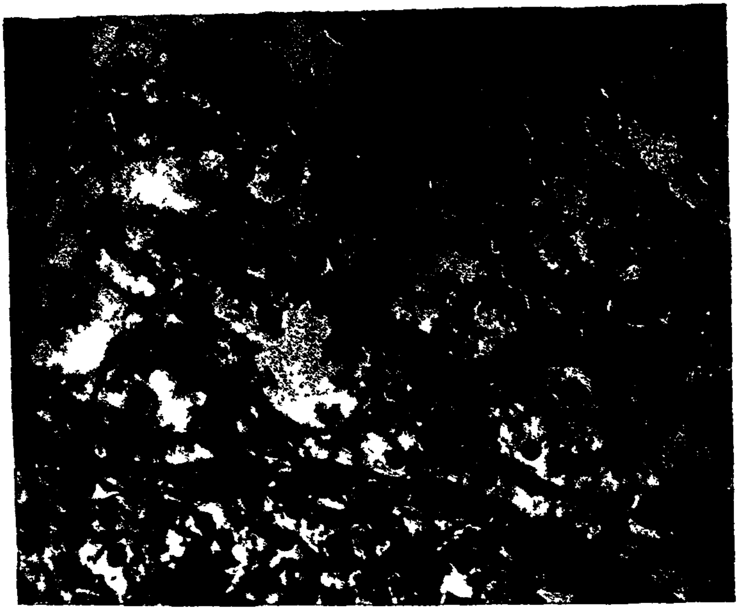


Figure 3—*Case 4* Pretreatment hematoxylin and and eosin stain photomicrograph to emphasize the thin areolar like quality of the supporting connective tissue seen in Figure 1 (X 400)

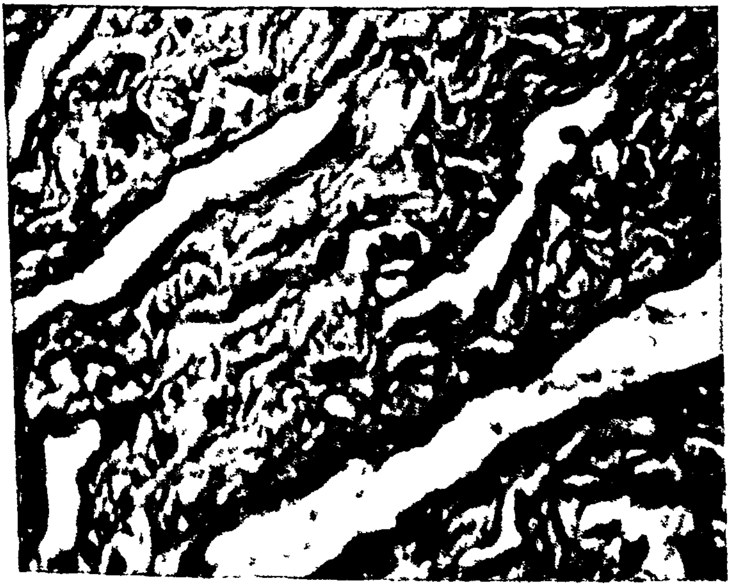


Figure 4—*Case 4* Post-treatment photomicrograph Hematoxylin and eosin stain shows the denseness and maturity of the connective tissue and the large vascular spaces in Figure 2 (X 400)

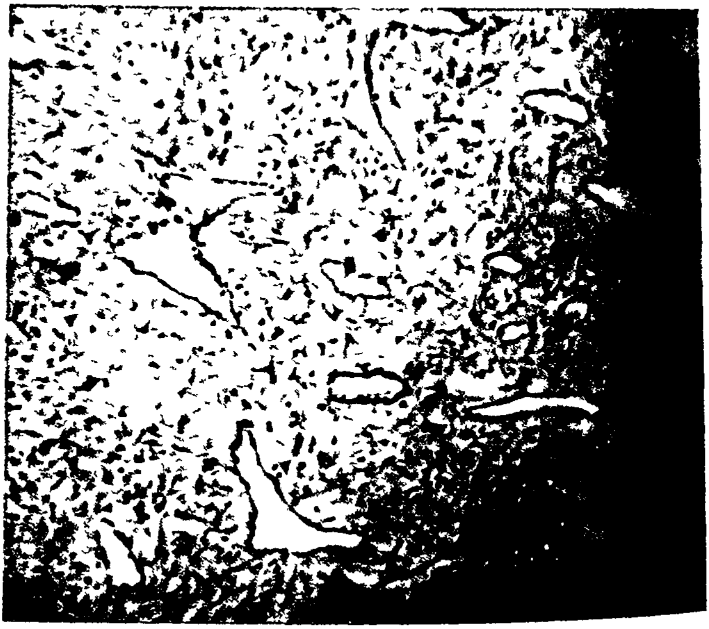


Figure 1—*Case 4* Pre-estrogen therapy photomicrograph Hematoxylin and eosin stain of the angio-fibroma shows many young and older endothelial lined spaces with a thin immature type of connective tissue stroma (X 180)

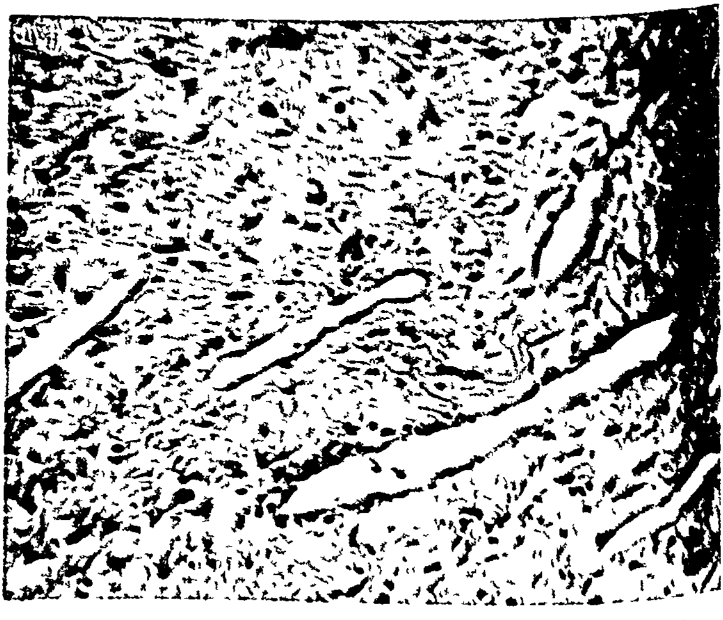


Figure 2—*Case 4* Post-estrogen therapy photomicrograph Hematoxylin and eosin stain of the angio-fibroma shows marked maturing of the connective tissue stroma with thick strands of collagen The blood vessels show a decrease in number but an increase in size and maturity (X 180)

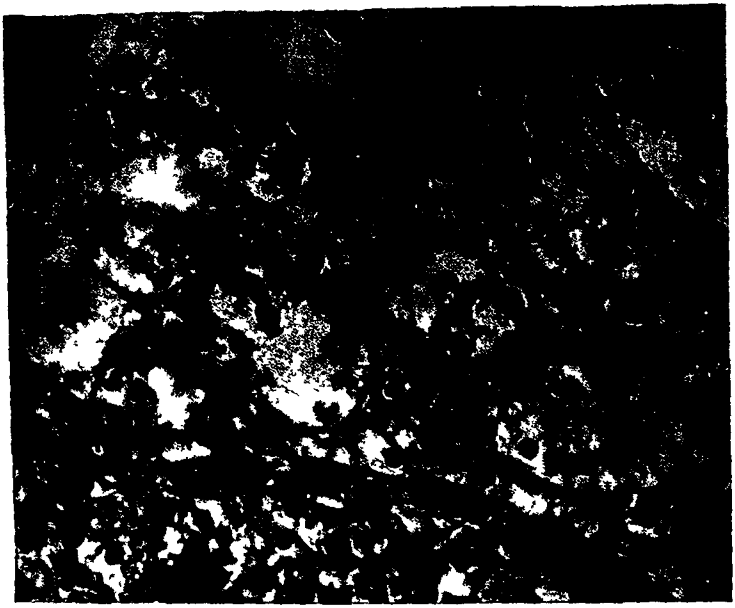


Figure 3.—*Case 4* Pretreatment hematoxylin and and eosin stain photomicrograph to emphasize the thin areolar like quality of the supporting connective tissue seen in Figure 1 (X 400)

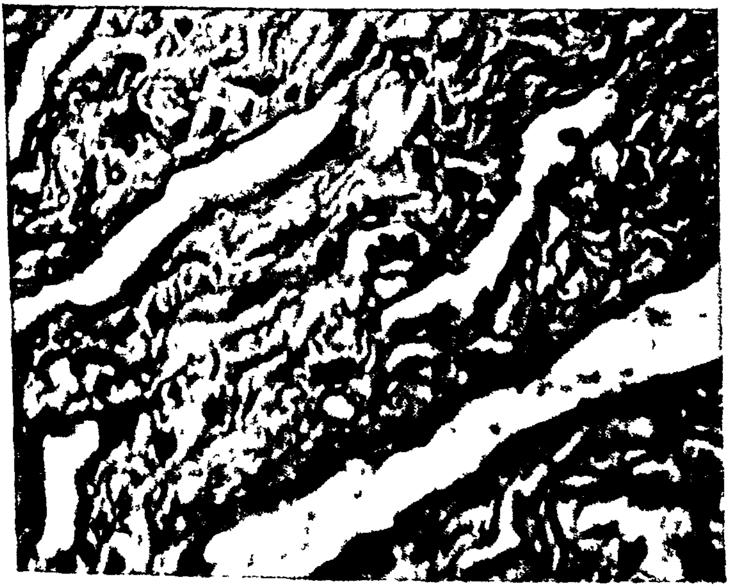


Figure 4.—*Case 4* Post-treatment photomicrograph Hematoxylin and eosin stain shows the denseness and maturity of the connective tissue and the large vascular spaces in Figure 2 (X 400)

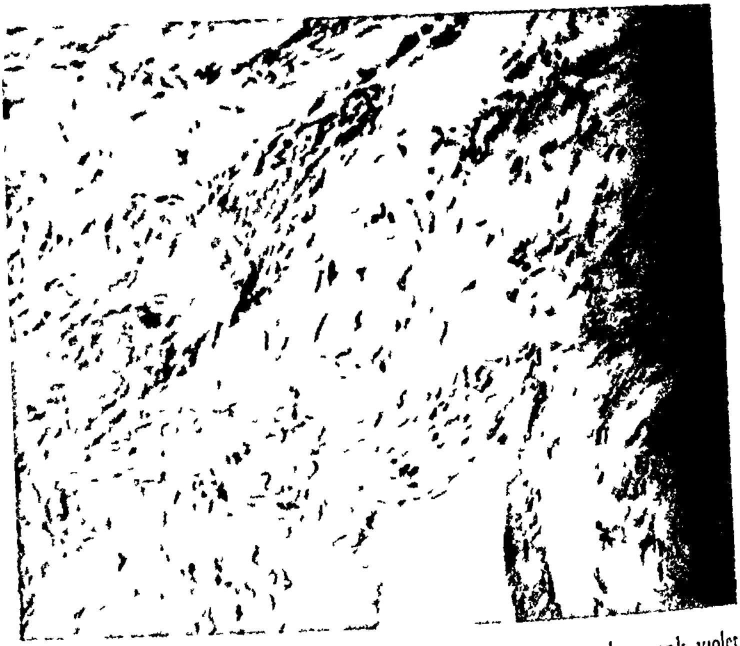


Figure 5—*Case 1* Toluidine blue stain shows the pink-violet metachromasia of the perivascular ground substance with numerous mast cells in this photomicrograph (X 180)

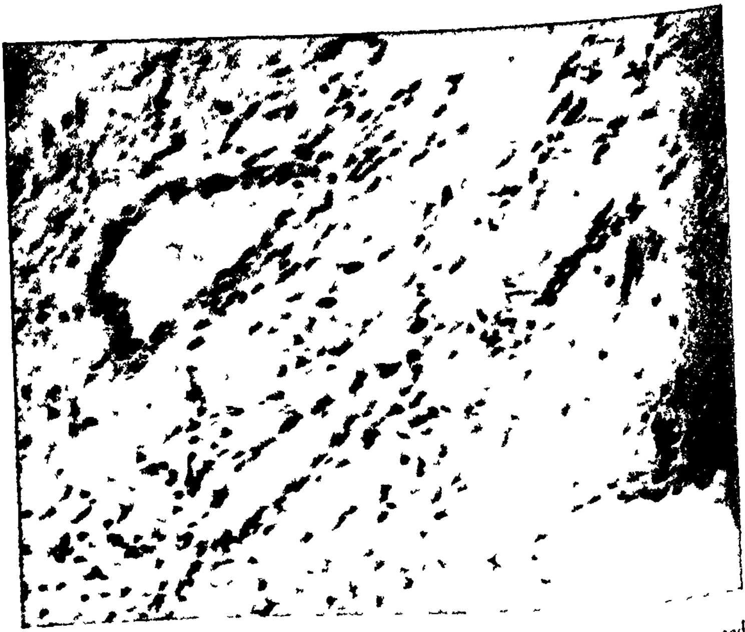


Figure 6—*Case 1* Photomicrograph Toluidine blue stain treated with 750 T R U Wydase The loss of metachromatic stain of the large polymer mucopolysaccharides is noted Mast cells are still clearly visible (X 180)

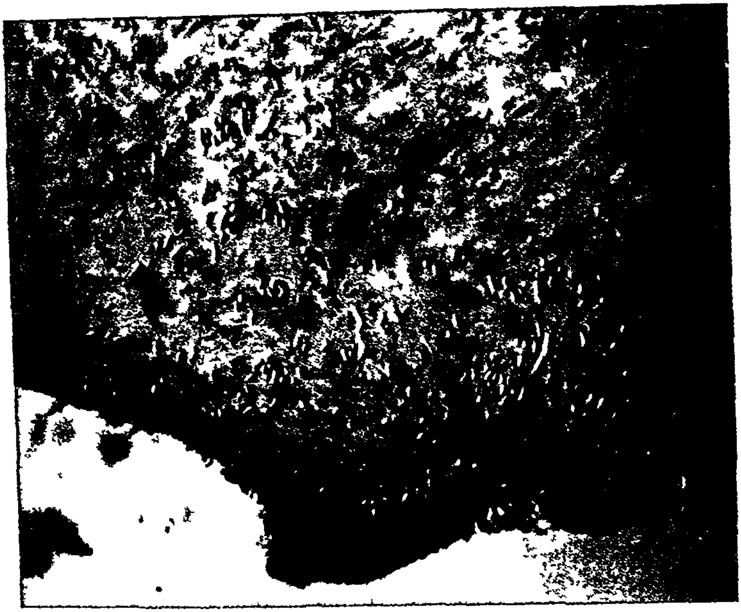


Figure 7—*Case 2* Photomicrograph Toluidine blue stain shows the pink-violet metachromasia of the ground substance together with many mast cells (X 180)

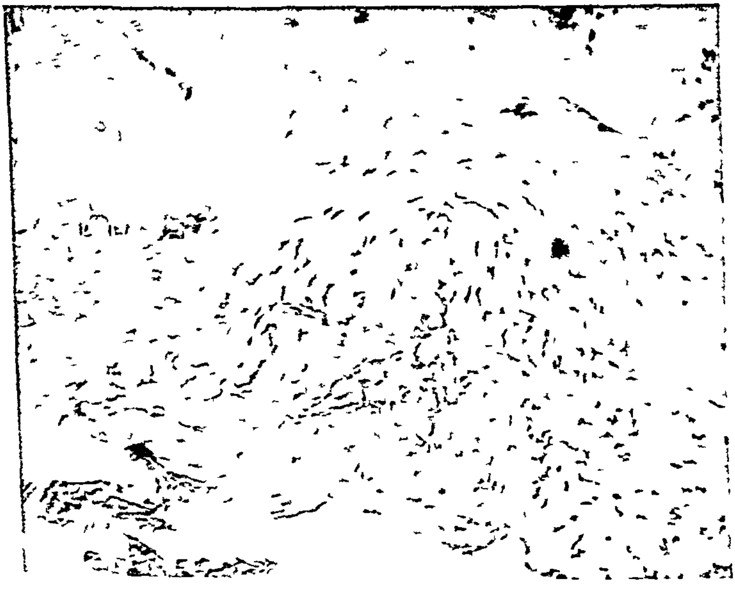
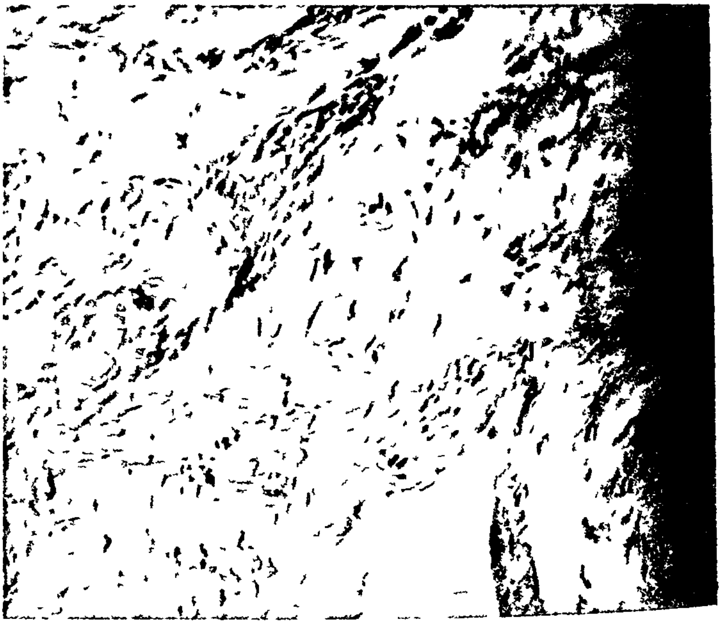


Figure 8—*Case 2* Photomicrograph Toluidine blue stain following incubation with 750 T R U Wydase There is almost a complete loss of the metachromasis following depolymerization Mast cells still are visible (X 180)



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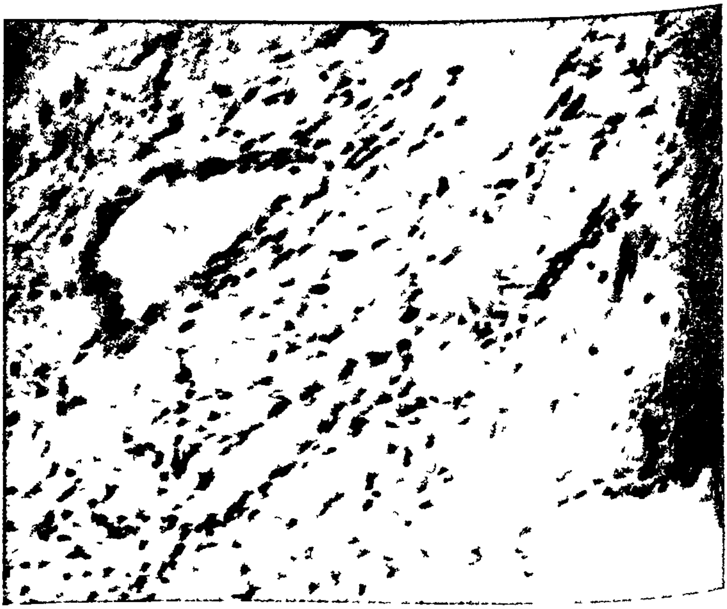

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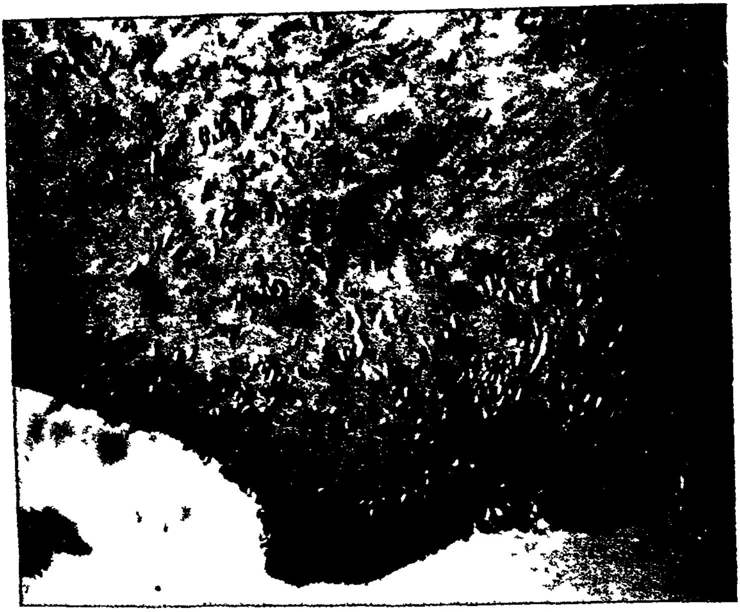

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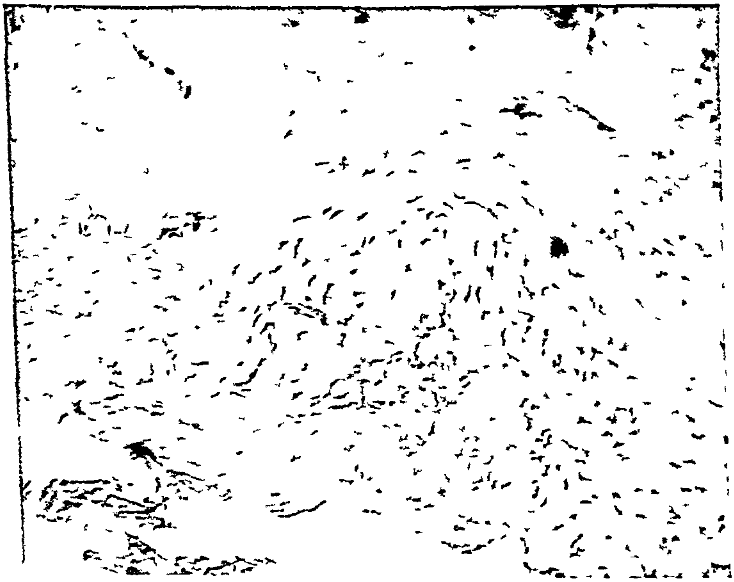

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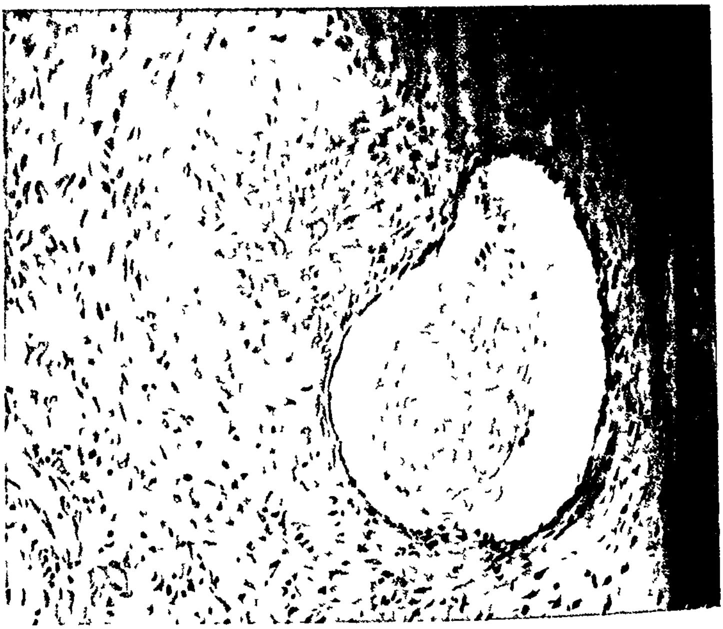


Figure 9—*Case 3* Photomicrograph Toluidine blue stain shows pink-violet metachromatic material about the vessel Mast cells well visualized (X 180)

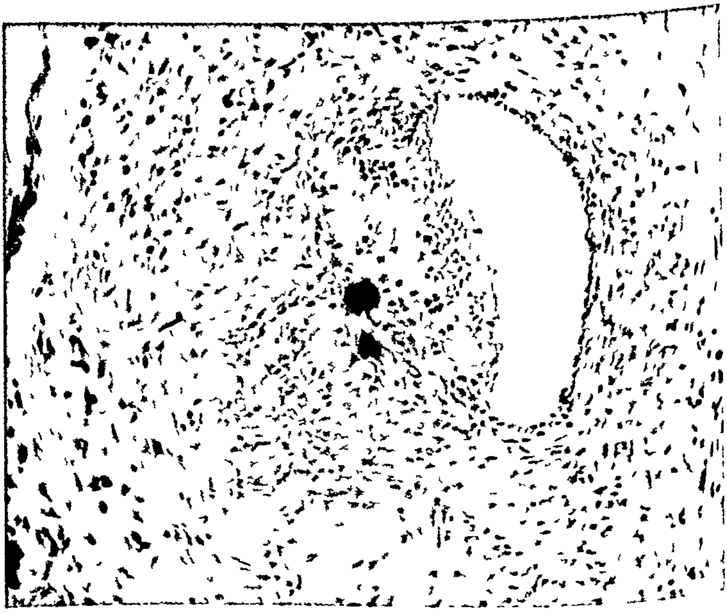


Figure 10—*Case 3* Photomicrograph Toluidine blue stain following incubation with 750 T R U Wydase Shows a considerable decrease in the metachromasis but mast cells still present (X 180)

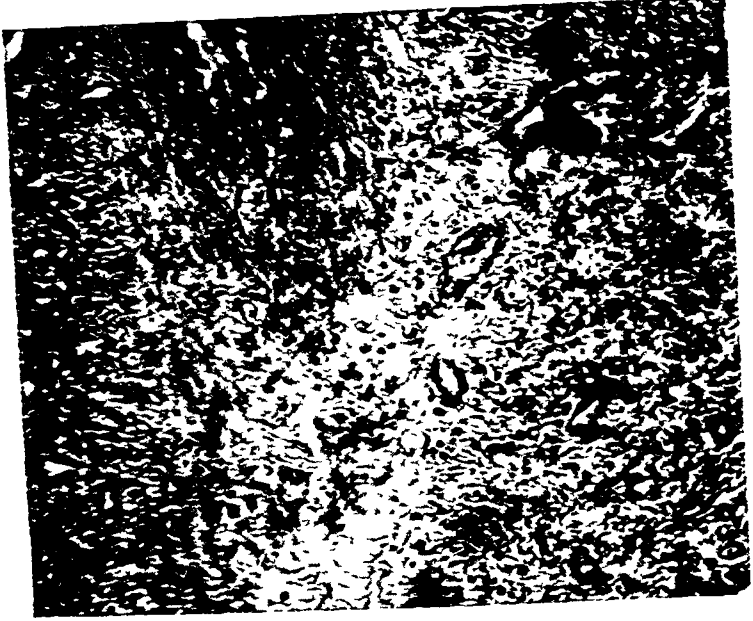


Figure 11—*Case 1* Photomicrograph Schiff periodic acid stain shows the general diffuse pink coloring of the perivascular mucopolysaccharides (X 180)

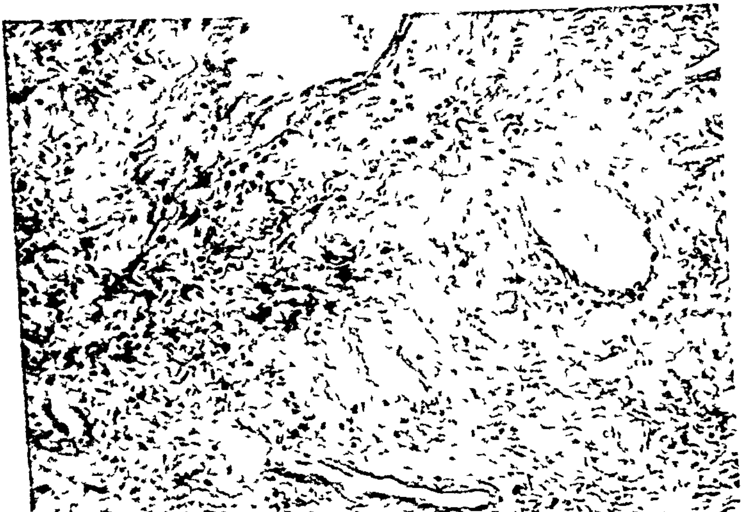


Figure 12—*Case 1* Photomicrograph Schiff periodic acid stain with 750 TRU Wydase Shows a decrease in the amount of perivascular pink coloring The nonspecific nature of the stain can be noted when compared with the untreated tissue (X 180)

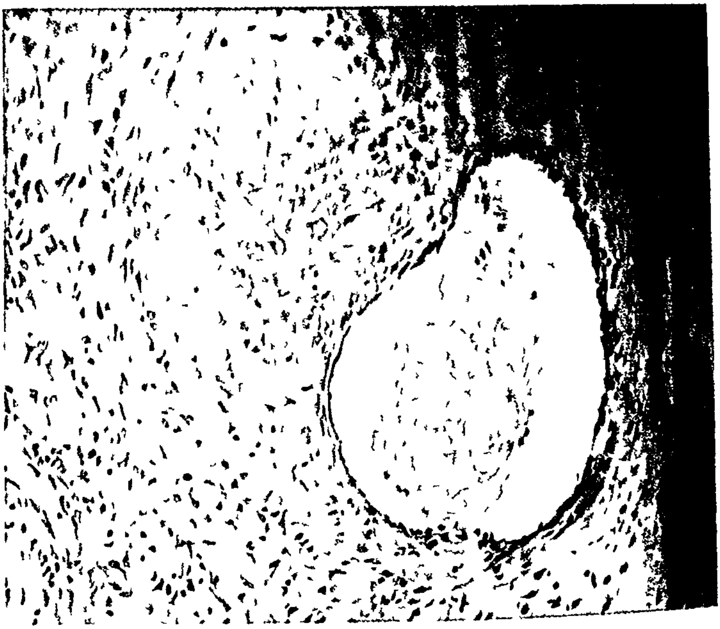


Figure 9—*Case 3* Photomicrograph Toluidine blue stain shows pink-violet metachromatic material about the vessel Mast cells well visualized (X 180)

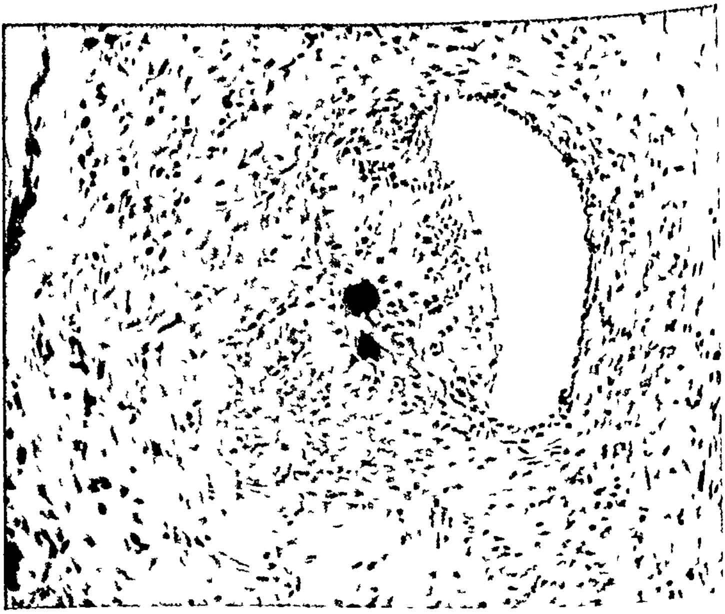


Figure 10—*Case 3* Photomicrograph Toluidine blue stain following incubation with 750 T R U Wydase Shows a considerable decrease in the metachromasis but mast cells still present (X 180)

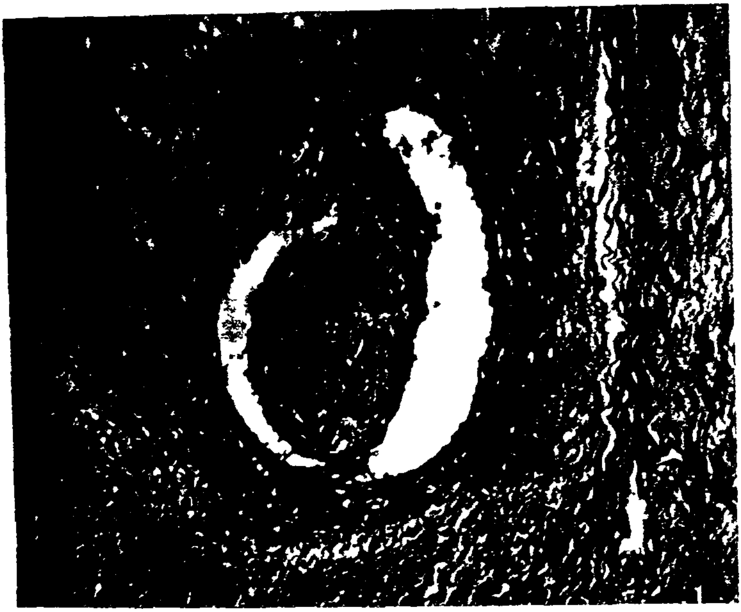


Figure 15.—*Case 3* Photomicrograph Schiff periodic acid stain shows the perivascular pink staining ground substance Collagen stains orange (X 180)

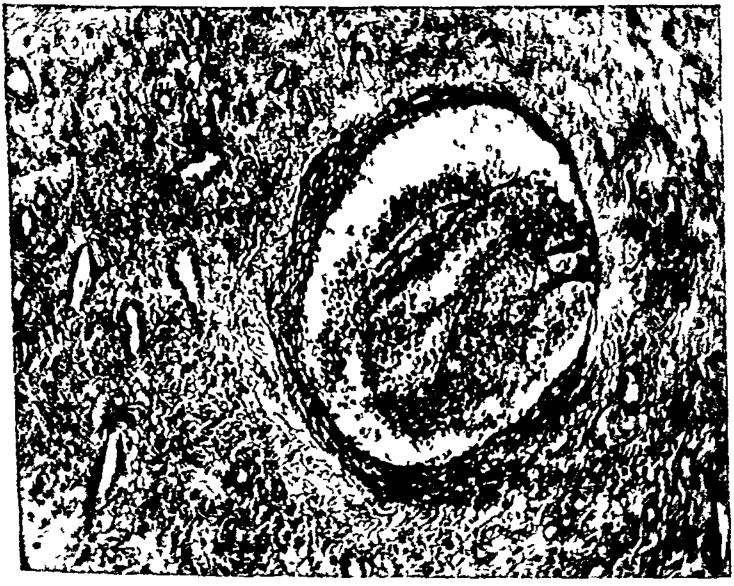


Figure 16.—*Case 3* Photomicrograph Schiff periodic acid stain following incubation with 750 T R U Wydase Stain is not remarkably different than untreated section There is a decrease in the perivascular stain. (X 180)

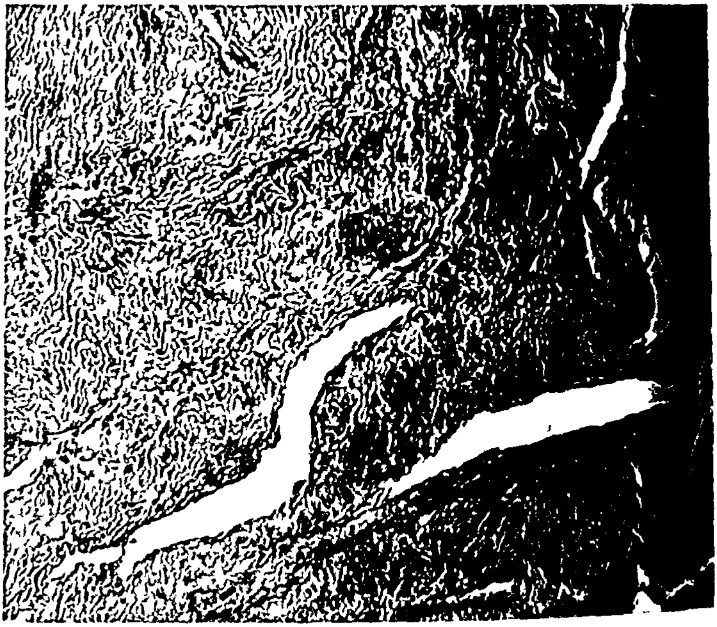


Figure 13—*Case 2* Photomicrograph Schiff periodic acid stain shows its nonspecific nature Collagen stains orange, and perivascular mucopolysaccharides are bright pink (X 180)

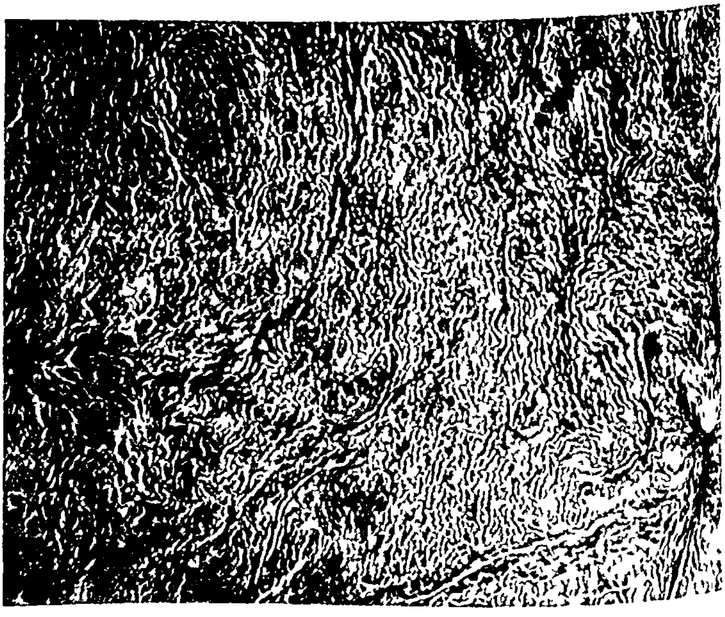


Figure 14—*Case 2* Photomicrograph Schiff periodic acid stain following incubation with 750 T R U Wydase Minimal changes noted as stain is non-specific for the size of the polymer (X 180)

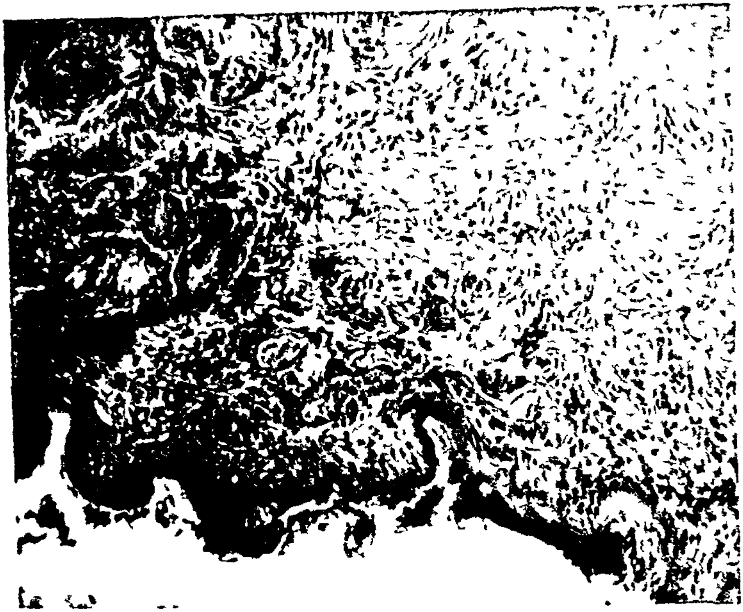


Figure 19—*Case 2* Colloidal iron stains show the unusual well marked basement membrane and the diffuse amount of mucopolysaccharides and mucoprotein (X 180)

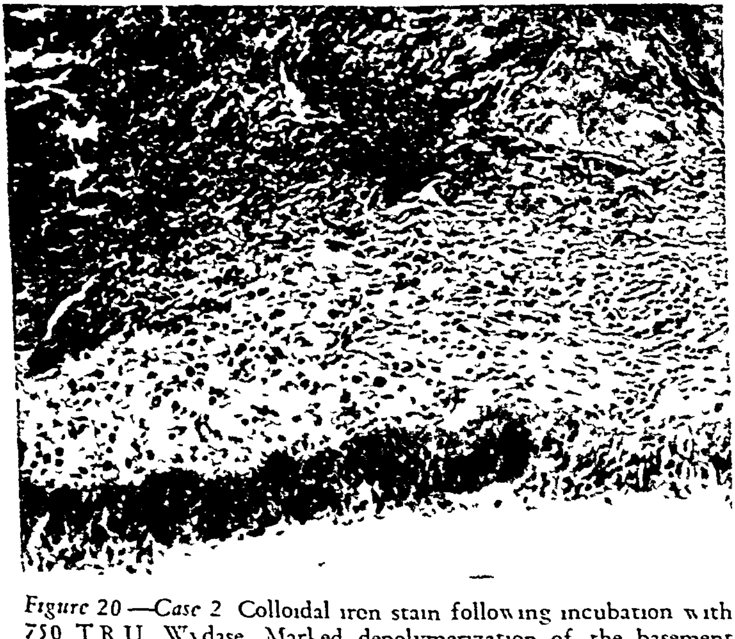


Figure 20—*Case 2* Colloidal iron stain following incubation with 750 T R U Wydase Marked depolymerization of the basement membrane and mucopolysaccharides are noted (X 180)

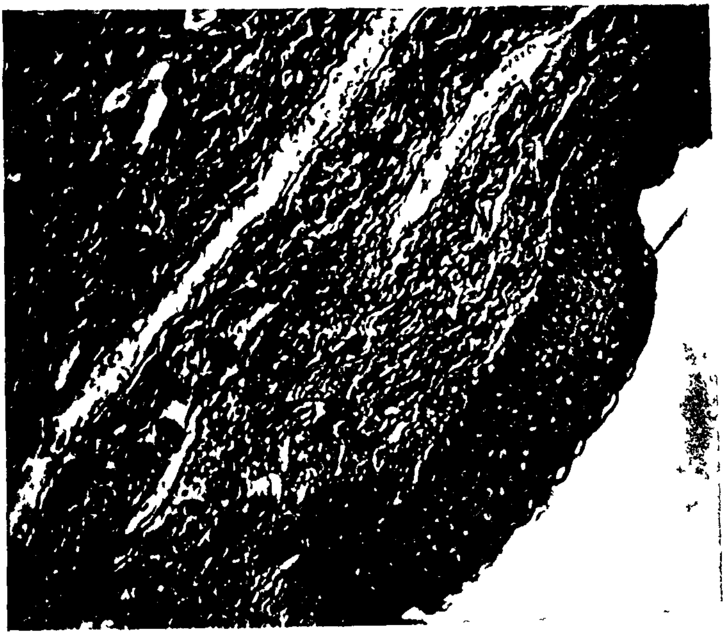


Figure 17.—Case 1. Photomicrograph. Colloidal iron stain shows blue stain of mucopolysaccharides in and about the blood vessels. Mature Collagen stains red. (X 180)

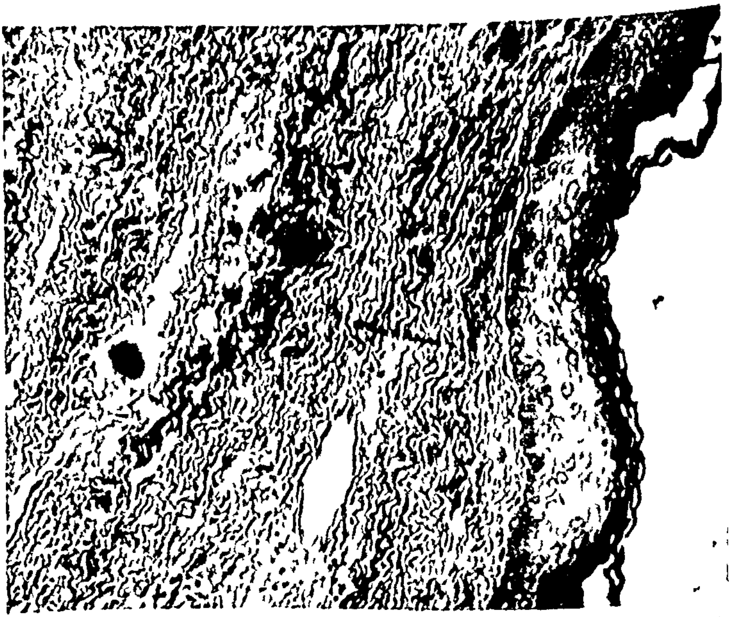


Figure 18.—Case 1. Photomicrograph. Colloidal iron stain following incubation with 750 T.R.U. Wydase. Minimal change in appearance of collagen, only slight decrease in perivascular ground substance. (X 180)

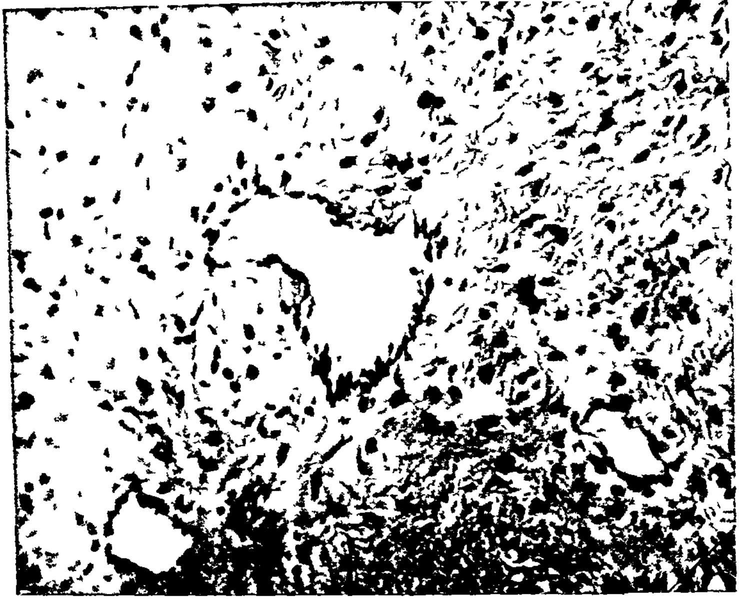


Figure 23—*Case 1* Postoperative photomicrograph Hematoxylin and eosin stain of the angiofibroma shows tumor containing vascular spaces with prominant and mature endothelial cells They are surrounded by fibrous connective tissue with some fibtoblasts visible There is no evidence of thrombosis of the vascular spaces, necrosis, or other changes attributable to radiation effect (X 180)

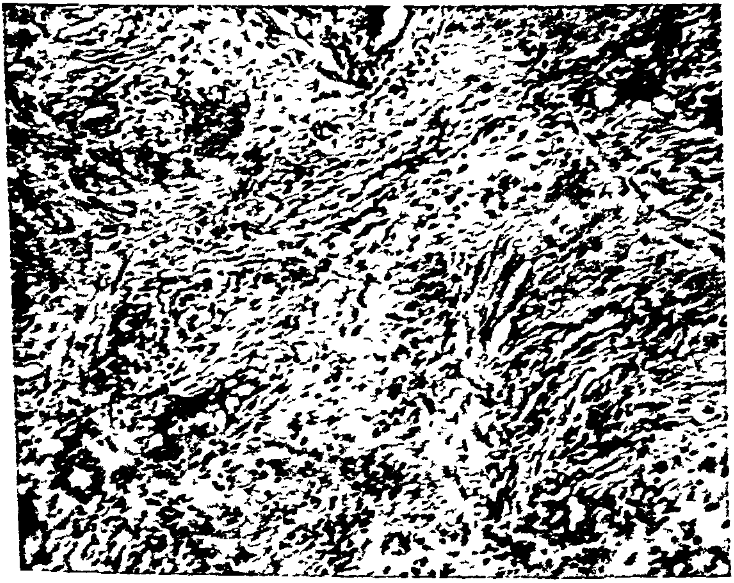


Figure 24—*Case 2* Photomicrograph Hematoxylin and eosin stain of angiofibroma shows some round cell infiltration together with areas of young and also mature vascular spaces Connective tissue shows various degrees of maturation (X 180)

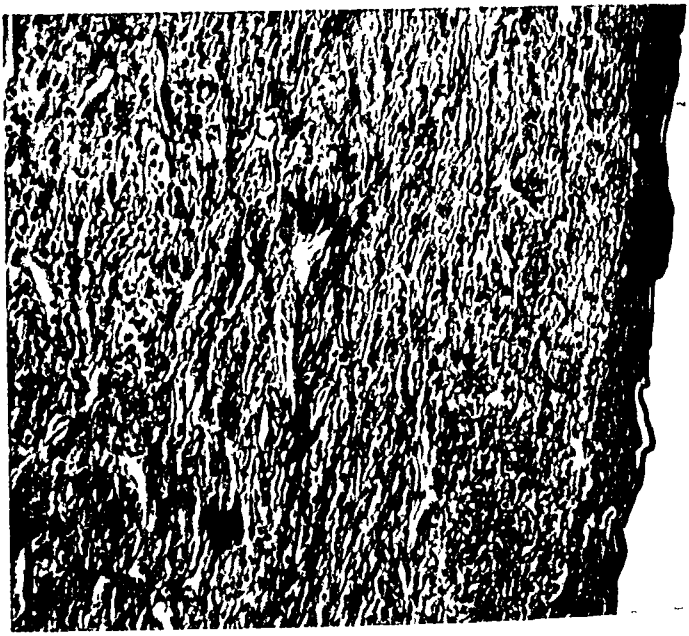


Figure 21 —*Case 2* Colloidal iron stain shows the abundance of blue staining ground substance particularly about the new vessel formations (X 180)

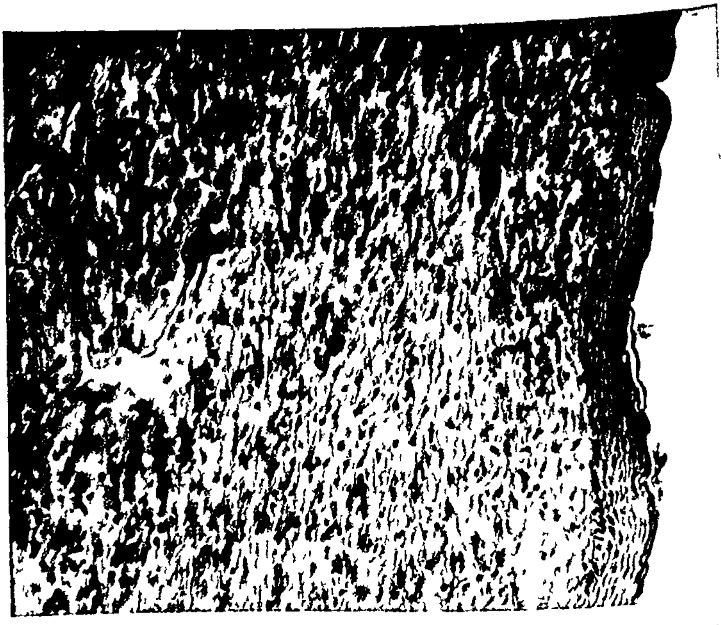
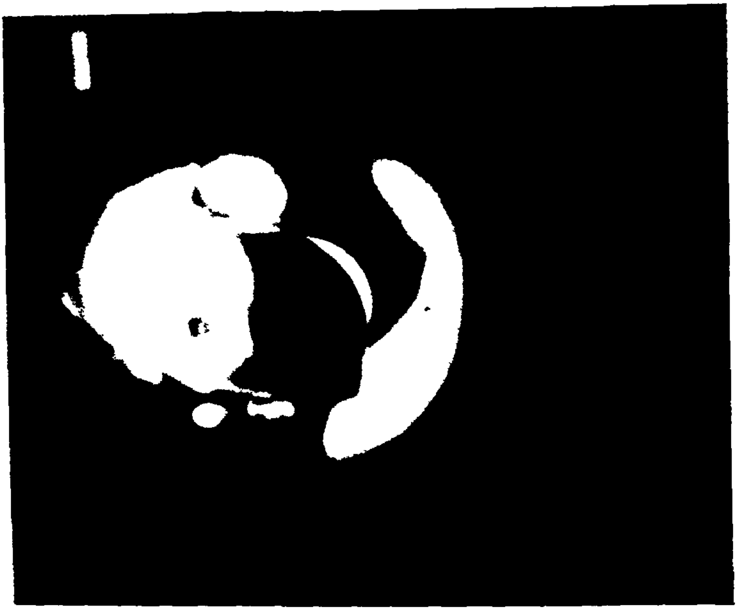
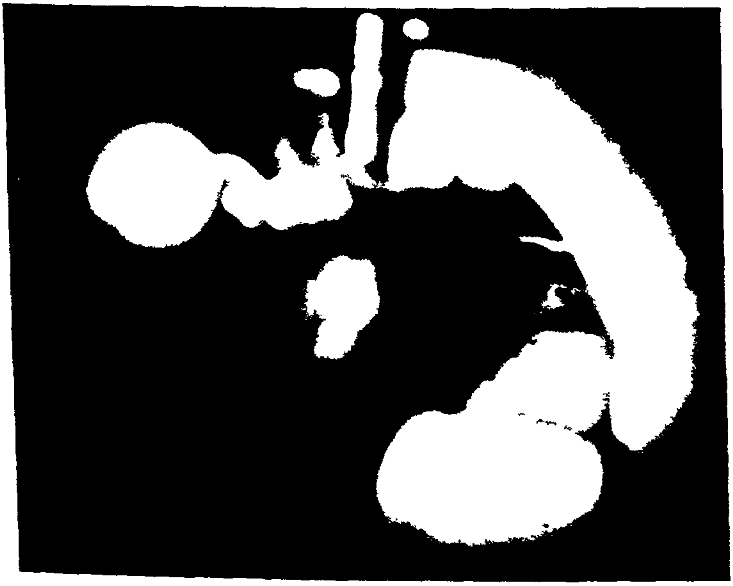


Figure 22 —*Case 3* Colloidal iron stain following incubation with 750 T R U Wydase There is a considerable loss in the metachromasia However, mast cells are still fairly visible (X 180)



Slide 2—*Case 1* Postoperative appearance of nasopharynx shows right eustachian tube and choana with no evidence of tumor within visible limits



Slide 3—*Case 2* Preoperative nasopharyngeal colored slide shows a large lobular mass in the nasopharynx, mostly on the left

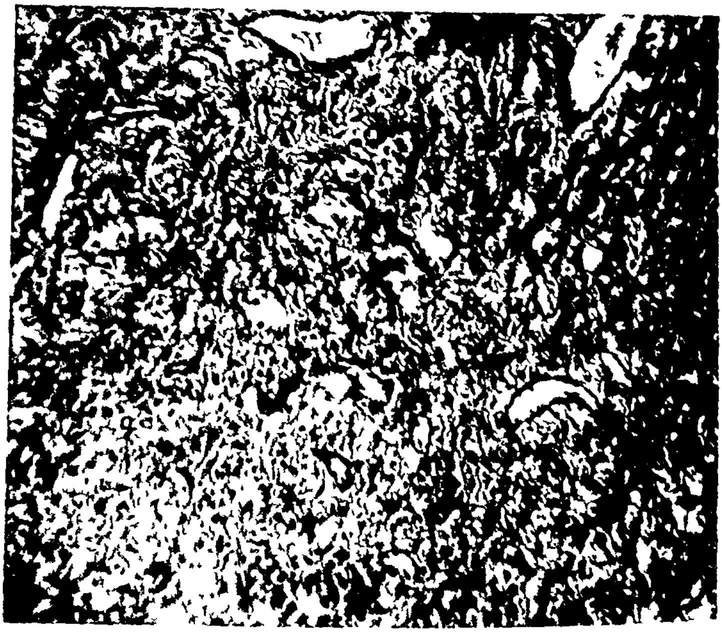


Figure 25—*Case 3* Photomicrograph Hematoxylin and eosin stain of angiofibroma shows many connective tissue strands many of which are fibroblasts Blood vessels are seen in various stages of development (X 180)

Slide 1—*Case 1* Preoperative nasopharyngeal colored slide shows the round red mass in the right nasopharynx with white exudate on its surface

which analyzed 29 cases of this tumor during a 20-year period, it was reported that none of these occurred in the female In contrast to this, the excellent comprehensive and analytic study by Figi and Davis[11] of 144 cases, reported over a 30-year period was divided into two groups the first group of 63 cases, reported between 1910-1939, included five females, or 7 9 per cent, in 51 cases reported from 1940-1949, all were males, or 0 per cent females, with an overall average of 4 4 per cent females for the entire series It is of considerable interest to speculate on the reason for the large statistical divergence between the first and second group of their series

The onset of symptoms varies from seven to 19 years, with an average of 14 years in one report,[12] and ten to 21 years of age, with an average of 18 years for the second series [11] It is estimated that the incidence of this tumor is 05 per cent of all neoplasms of the head and neck The signs and symptoms of this entity have a general march of progression and almost invariably occur in the following order Nasal obstruction, recurrent epistaxis, progressive deformity of the palate, face, and throat, rhinolalia, and anosmia, not infrequently, however, alarming epistaxis may be the first complaint The march of symptoms is usually brought to an abrupt halt by the thorough and astute observations of the first clinician to examine the patient This fact becomes more impressive when it is realized that symptoms in one series were present from one month to six years with an average of one and one-half years Because of the extreme vascularity of the tumor, heroic measures are often required to control bleeding These may be from tamponade to bilateral carotid ligation The general clinical course of the disease is such that constant observation is necessary, and the proper selection of both time and method for definitive treatment is of utmost importance

DIFFERENTIAL DIAGNOSIS

It is extremely important to make a differential diagnosis between the angiofibroma and any of the other tumors which occur in the nasopharynx The general characteristic of this tumor is a smooth, occasionally lobular, firm, hard, red mass

Slide 4 —Case 2 Postoperative nasopharyngeal colored slide shows the absence of the tumor with the left posterior naris and choana visible

Slide 5 (Not Shown) *Case 3* Preoperative nasopharyngeal colored slide shows a large mass in the nasopharynx, predominently on the left

Slide 6 (Not Shown) *Case 3* Preoperative, post-estrogen, colored slide of nasopharynx shows a change in color and size of the tumor mass

Slide 7 (Not Shown) *Case 3* Postoperative colored slide shows a spacious nasopharynx but a recurrence visible in the center of the mirror

Slide 8 —Case 4 Preoperative, pre-estrogen nasopharyngeal colored slide shows a smooth red tumor mass on the right with some visibility of the left choana

Slide 9 (Not Shown) *Case 4* Preoperative, post-estrogen therapy, nasopharyngeal colored slide shows the degree of the recession of the tumor, 36 days after treatment, to the extent of being able to see the right eustachian tube and part of the right choana superiorly

Slide 10 —Case 4 Postoperative nasopharyngeal colored slide shows absence of the tumor and the clear visibility in the mirror of the right eustachian tube and the posterior tips of the middle and inferior turbinates

haired, white male, was admitted to the first hospital on Jan 23, 1950, with the complaint of difficulty in breathing through the right nostril and recurrent epistaxis for the previous nine months On Jan 26, removal of the red, firm tumor mass from the right nasopharynx was attempted but not completed due to excessive bleeding however, the specimen was reported as juvenile angiofibroma On Feb 3, a large tumor mass was removed from the nasopharynx with electrocautery, but the excision was not considered complete Profuse bleeding occurred during the operation and for the following two weeks He received 1600 *r* of X radiation in an attempt to scarify the tumor and prevent further bleeding This was followed by an acute respiratory infection and otitis media, which responded to penicillin therapy On April 19 he was discharged from the hospital with a moderate sized mass still present in the right choana On Aug 31 he was admitted to a second hospital because of recurrent epistaxis and difficulty in breathing On Sept 22 he was transferred to this hospital for definitive treatment

On physical examination a firm, pale red mass was seen in the nasopharynx and after detailed study appeared to be attached to the medial plate of the right pterygoid and the base of the sphenoid across the midline (see Slide 1) The remainder of the physical examination was essentially normal except for hypertrophy of the tonsils

Laboratory studies revealed a normal hemogram with 7500 white blood cells, 14 gm hemoglobin, and a platelet count of 213,000 The Kahn test was negative, urine, normal, bleeding and clotting time, normal

X ray examination revealed a mass about 3 cm in diameter lying in the nasopharynx on the right No osseous destruction was noted Diffuse clouding of the right antrum and ethmoids was also noted After a discussion at the Tumor Board, it was suggested that additional X-ray therapy be tried and 1800 *r* at the skin was delivered *via* two alternating portals of 300 *r* daily for a total depth dose of 2970 *r* This did not seem to arrest the growth of the tumor, and since the patient had had surgery and two courses of X ray therapy, a consultation was arranged with Hayes Martin, M D, who suggested testosterone but believed that surgery would eventually be necessary This proved to be the case The patient was given 25 mg of testosterone propionate, q i d, for 36 days The tumor did not appear to grow, but neither was there much evidence of involution On Jan 24, 1951, the right external carotid was ligated, the right middle turbinate removed, and the entire mass evulsed with a cold snare of especially heavy piano wire When this snare was firmly in place through the nose, a cut was made on the prevertebral fascia via the mouth and extended to the periosteum of the sphenoid—not disturbing the tumor This permitted a plane of cleavage, along which the evulsion could take place With a pull of tremendous force, the tumor tore free from the nasopharynx taking with it the anterior wall of the right sphenoid with its sphenopalatine artery The bleeding that followed was brisk but quickly controlled when a few small remaining pieces of tumor were removed (see Fig 23) A postnasal pack was used to control the slight postoperative bleeding The nose was unpacked and bleeding was minimal until Feb 3, when the patient suddenly began to bleed profusely This was rapidly controlled by fulgurating the area of the evulsed sphenopalatine artery From this time on, healing was uneventful and the nasopharynx appeared clear except for a small, suspicious granular mass in the right fossa of Rosenmueller A biopsy was taken and found to be granulation tissue All other check biopsies from this area were negative The patient has had no recurrence (see Slide 2)

Case 2 D R a 53 year old, auburn haired, well developed well nourished, white male first noticed difficulty in breathing at age 18, while with occasional areas of ulceration and exudation, depending upon the amount of bleeding, trauma, or secondary infection which has been present previously These characteristics differ greatly from nasopharyngeal carcinoma, and the differential diagnosis for this entity is not difficult The chordoma in this area might well produce some confusion, but roentgenographic diagnostic studies should be of considerable help

Adenoid tissue may cause nasal obstruction but is easily differentiated by the characteristic, soft, irregular mass along the mucosa

Benign tumors of the salivary gland in the nasopharynx may be firm like an angiofibroma, but their appearance and location should make the diagnosis apparent Chondrosarcoma or angiosarcoma can produce a considerable amount of confusion This has been noted in detail in the case report by Wirth and Shimkin[28] Even tissue obtained by biopsy in the early stage of the disease failed to reveal the true nature of the tumor The diagnosis was later confirmed at secondary and tertiary surgical procedures, and also at necropsy when metastatic areas were found in the lung fields The appearance of pulmonary metastases would immediately mitigate against a diagnosis of angiofibroma, however, the most common tumor for which a differential diagnosis must be made is the choanal polyp In general, this is not difficult, for the choanal polyp has its characteristic smooth, glistening surface and a pale, edematous, translucent appearance There is usually very little definite redness to the tumor, and occasionally a few dilated vessels may be seen on the surface One of the most important and yet often neglected part of an examination for nasopharyngeal tumor is the digital palpation The difference in the feeling of a choanal polyp to the finger and that of an angiofibroma is so contrasting that seldom will one be led astray If the index of suspicion for this vascular tumor remains high, the accidental removal of a misdiagnosed polyp, with its subsequent massive hemorrhage, would be avoided

CASE REPORTS

Case 1 E G R , Jr a 20 year old, well developed, well nourished brown haired white male, was admitted to the first hospital on Jan 23, 1950, with the complaint of difficulty in breathing through the right nostril and recurrent epistaxis for the previous nine months On Jan 26, removal of the red, firm tumor mass from the right nasopharynx was attempted but not completed due to excessive bleeding however, the specimen was reported as juvenile angiofibroma On Feb 3, a large tumor mass was removed from the nasopharynx with electrocautery, but the excision was not considered complete Profuse bleeding occurred during the operation and for the following two weeks He received 1600 *r* of X radiation in an attempt to scarify the tumor and prevent further bleeding This was followed by an acute respiratory infection and otitis media, which responded to penicillin therapy On April 19 he was discharged from the hospital with a moderate sized mass still present in the right choana On Aug 31 he was admitted to a second hospital because of recurrent epistaxis and difficulty in breathing On Sept 22 he was transferred to this hospital for definitive treatment

On physical examination a firm, pale red mass was seen in the nasopharynx and after detailed study appeared to be attached to the medial plate of the right pterygoid and the base of the sphenoid across the midline (see Slide 1) The remainder of the physical examination was essentially normal except for hypertrophy of the tonsils

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X ray examination revealed a mass about 3 cm in diameter lying in the nasopharynx on the right No osseous destruction was noted Diffuse clouding of the right antrum and ethmoids was also noted After a discussion at the Tumor Board, it was suggested that additional X-ray therapy be tried and 1800 *r* at the skin was delivered *via* two alternating portals of 300 *r* daily for a total depth dose of 2970 *r* This did not seem to arrest the growth of the tumor, and since the patient had had surgery and two courses of X ray therapy a consultation was arranged with Hayes Martin, M D who suggested testosterone but believed that surgery would eventually be necessary This proved to be the case The patient was given 25 mg of testosterone propionate, q i d , for 36 days The tumor did not appear to grow, but neither was there much evidence of involution On Jan 24, 1951, the right external carotid was ligated, the right middle turbinate removed, and the entire mass evulsed with a cold snare of especially heavy piano wire When this snare was firmly in place through the nose, a cut was made on the prevertebral fascia via the mouth and extended to the periosteum of the sphenoid—not disturbing the tumor This permitted a plane of cleavage, along which the evulsion could take place With a pull of tremendous force, the tumor tore free from the nasopharynx taking with it the anterior wall of the right sphenoid with its sphenopalatine artery The bleeding that followed was brisk but quickly controlled when a few small remaining pieces of tumor were removed (see Fig 23) A postnasal pack was used to control the slight postoperative bleeding The nose was unpacked and bleeding was minimal until Feb 3 when the patient suddenly began to bleed profusely This was rapidly controlled by fulgurating the area of the evulsed sphenopalatine artery From this time on, healing was uneventful and the nasopharynx appeared clear except for a small suspicious, granular mass in the right fossa of Rosenmueller A biopsy was taken and found to be granulation tissue All other check biopsies from this area were negative The patient has had no recurrence (see Slide 2)

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CASE REPORTS

Case 1 E G R, Jr a 20 year old, well developed, well nourished brown evidence of recurrence was noted at any time and the patient was discharged on Dec 7, 1951 (see Slide 4)

Case 3 W E, a 23-year-old well developed, well nourished married, white male with carrot red hair, was admitted to the first hospital on Sept 12, 1951, and transferred to this hospital three days later for definitive treatment His chief complaint was recurrent nosebleed and progressive difficulty in breathing on the left He had a history of severe nasal hemorrhage dating from age 18 in the last year of high school These were treated but no one looked in his nasopharynx until admission to this hospital

The physical examination was essentally normal except for a large mass, 2 5x2x2 75 cm filling the entire left choana and extending down into the area of the prevertebral fascia on the left (see Slide 5) The mass appeared to be attached to the posterior and lateral wall of the left nasopharynx The patient had freckles red hair, and a gynecoid distribution of pubic hair Genitalia were normal

Laboratory studies showed normal urinalysis and hemogram

X-ray examination demonstrated well developed sinuses The frontal sinuses were somewhat larger than normal as often seen in pituitary overactivity The mass was observed in the left nasopharynx, but no erosion or invasion was visualized

It was decided to try estrogen therapy in this case since androgen therapy produced some change but not adequate involution The patient was given 5 mg of estrogen (Stilbesterol) three times daily for one month During this time he noted enlargement of the breast and a decrease in libido This having been explained to the patient and his wife beforehand did not disturb the family relationship During the period of estrogen therapy, there was a very definite change in appearance of the tumor from a large red, swollen, firm mass to one that was considerably smaller and which had become pale purple in color, suggesting that of an allergic mucosa (see Slide 6) The tumor had become almost stony hard to palpation

It had been previously decided to remove the tumor regardless of the response to hormonal therapy On Jan 16, 1952, under pentothal endotracheal anesthesia with a cuff the left inferior turbinate was removed the tumor was grasped with a heavy piano wire snare and an attempt was made to evulse it as had been done in previous cases The greater portion of the tumor came free from the anterior wall of the sphenoid (see Fig 25) however there appeared to be some residuum on the medial pterygoid plate and some small areas of involvement of the prevertebral tissue down to the C-1 This was removed with a cutting cautery loop Blood loss was moderate and brisk but apparently considerably less than in the previously treated cases One thousand cubic centimeters of blood was replaced while in the operating room This was more than adequate

The postoperative course was uneventful except for the removal of the last of the packs on the fifth day resulting in a brisk severe hemorrhage which was controlled by packing and extensive cautery Five hundred centimeters of blood was again replaced

On Feb 25 a check biopsy from the left lateral wall of the nasopharynx revealed residual tumor This area was extensively fulgerized on April 12 The patient remained asymtomatic until May 8 1953 when he returned with some swelling on the left cheek Re-examination revealed a small nub of tissue of the lateral wall of the nasopharynx posteriorly (see Slide 7) Biopsy of this tissue revealed juvenile angiofibroma Lateral X rays of the skull and sinuses demonstrated a probable involvement of in school. At age 20 he had an operation for a deviated nasal septum, after which his breathing was not improved. In March, 1951, he was operated upon for adhesions in the nasal airway to relieve the increasing nasal obstruction. The tumor was first discovered at that time. On March 26, an attempt was made to remove the nasal tumor, but only half of it was excised. The blood loss was about 600 cc. The patient was transferred on June 6 to this hospital for definitive treatment.

On admission the physical examination proved to be essentially negative except for a red, firm mass, 2x2.5x3 cm., attached to the left lateral nasal wall and medial pterygoid plate, obstructing the entire left choana (see Slide 3). A small subdigastric node was palpable on the left. Pubic hair distribution was of gynecoid type. Genitalia were slightly underdeveloped for his age.

Laboratory studies revealed essentally normal urinalysis and hemogram. The white blood cell count was 6800; hemoglobin, 14 gm.

Chest X-ray was normal. X-ray of the skull showed a mass in the nasopharynx measuring 2.5x3x3.5 cm. The anterior, medial, and inferior margins appeared to be free but seemed to merge into the bony structures along the superior and lateral margins. There was no evidence of erosion and invasion.

Because of a history of allergies, appropriate tests were performed showing a 3+ reaction to chicken, nuts, green peppers, malt, and house dust. The patient was given 25 mg. of testosterone propionate, q.i.d., for two months, with no dramatic change; however, the growth did not seem to have increased, and slight involution was suggested.

On July 11, under pentothal anesthesia with endotracheal cuff, the left middle and inferior turbinates were removed and the tumor mass well visualized. An attempt was made to remove the tumor with the cautery snare, but only a portion was excised and massive bleeding ensued. This was controlled by a packing. With biting forceps, working *via* the nose and mouth combined, the mucosa was stripped off the prevertebral fascia and the periosteum elevated off the base of the sphenoid. With considerable force this was evulsed taking with it almost the entire tumor and part of the anterior wall of the sphenoid. The bleeding that followed again was brisk and vigorous but as in other procedures when cleaned down to bare bone, it was easily controlled. About 1500 cc. of blood loss was replaced during surgery. Firm anterior and posterior packs were inserted, and the patient was returned to the ward in good condition. The pathologic report was "juvenile angiofibroma" (see Fig. 24).

On the fifth postoperative day, the last of the packs was removed and brisk, bright red bleeding began. This was easily controlled by precise suction cautery to the antero-superior wall of the sphenoid and the nasopharynx repacked. On July 19, eight days after surgery, the patient complained of headache, was listless, lethargic and developed a swelling of the left cheek. His fever rose to 104.2° F. A repeat complete physical examination at that time failed to show any neurologic or systemic cause for this marked elevation. It was assumed that this probably represented a thrombosis in the pterygomaxillary space. The patient was placed on a regimen of aspirin and forced fluids in addition to the systemic penicillin and aureomycin he had already been given. The following day 3 to 4 ft. of vaseline packing was removed and the bleeding was controlled by cautery. No repacking was necessary. On July 21 the patient had improved considerably and the edema of the left side of the face had subsided to a large extent. Continuous inspection of the nasopharynx revealed only a small nubbin of tissue on the lateral wall. This was eventually removed and the pathologic report was "pyogenic granuloma." The nasopharynx was cleaned of crust by saline irrigation. No

A cut was made through the periosteum of the sphenoid and elevated below the attachment of the tumor This gave a plane of cleavage for the evulsion of the tumor on this occasion. Considerable force was required to tear the tumor free, and it came out with a good margin of normal mucosa. The time required for its removal was very short by comparison, and the blood loss was estimated at only 250 cc Some difficulty was encountered in getting this mass of tissue out through the right naris since its macroscopic measurement on removal was 3x4x1 3 cm. The nasopharynx, being packed off the mass was manipulated from its entrapment in the right external nasal vestibule On gross sectioning of the specimen, several cystic-looking spaces were noted one having a transverse diameter of 0 6 cm The tumor appeared to have been removed in its entirety at this time (see Slide 10)

The postoperative course was uneventful, with no major hemorrhages when the packing was removed. The nasopharynx healed so well that it was difficult to believe the size and source of the original tumor Follow-up check in 1956 revealed no evidence of recurrence

It is with considerable regret that, due to conditions beyond our control histochemical studies of this case were not possible

TREATMENT

Treatment for juvenile angiofibroma may be placed in several categories, however, the individual therapy of a given case must be equated and treated as a specific problem of its own. Since this tumor is generally benign, but locally malignant, it should be treated with this in mind It is felt by many authorities that the mass will involute and present no further problem for the patient As has been previously noted, the authors with the largest series are in complete disagreement with this feeling An early decision for treatment will appear to be highly advantageous Waiting for the expected involution of this tumor is but to wait for the tumor to grow bigger and present more problems at a later date

Local Chemical Therapy

The use of local chemical sclerosing agents is a natural thought that occurs when treating tumors which are essentially vascular in nature. McFarland[52] used the following chemicals two per cent phenol, lithium salicylate, snake venom, and sodium morrhuate. His conclusion was that none of these altered the course of the tumor, favorably or adversely. Sclerosing injections were also used by Figi and Davis[11] in one case. In general, however, injections of this type have little benefit to offer and few present advocates for its use The injection site bleeds, and if tissue sloughs, there is then a the left pterygomaxillary space He was given a course of X ray therapy through two portals for a total of 2600 r tissue dose This was supplemented by radon seeding of 6 mc of the pterygomaxillary space *via* a Caldwell Luc approach The posterior wall of the left antrum during surgery appeared to be paper thin, with a highly vascular tumor beneath its periosteum A series of radon seeds was geometrically inserted so as to increase the tissue dose to a total of about 3700 *r* On June 4, the swelling appeared to have decreased almost entirely, and no tumor was visible The patient was discharged from the hospital with the tumor apparently under control In October, 1955, the author was notified by letter of the recurrence of the tumor, and in the early part of 1956 an extensive exenteration of the left pterygomaxillary space was performed

Case 4 L P, a 20-year old, well developed, well nourished, white male, with carrot red hair, was admitted to this hospital on March 20, 1952, with the chief complaint of progressive difficulty in breathing through the right side of the nose No history of epistaxis was present Nasal obstruction started about one year prior to admission Being the fourth case of this tumor seen within a period of two years, the preoperative diagnosis was made immediately

The physical examination was essentially normal except for a red, firm tumor, 1 5x2x3 cm, seen in the nasopharynx, mostly on the right and free on all surfaces except for its attachment to the anterior wall of the right sphenoid and right medial pterygoid plate (see Slide 8) The hair distribution was essentially normal Genitalia were smaller than usual for the patient's age

Laboratory examinations showed normal hemograms and urinalysis

X ray examinations demonstrated a 2x2x3 cm mass in the right nasopharynx Some clouding of the right ethmoid was also noted

Because of previous experience in endocrine therapy, it was decided to take a biopsy specimen of the tumor prior to instituting estrogen therapy to see whether the clinical evidence was confirmed by microscopic proof of changes in the nature of this tumor On May 20, three pieces of tissue were removed from different sections of the tumor (see Fig 1) This was to insure proper sampling The bleeding was brisk and bright red, with each bite, but it was readily controlled by suction cautery

Following this, a course of estrogen therapy, (Stilbesterol) 5 mg three times daily for a month, was given Enlargement and discomfort of the breasts were noted, together with a loss of libido At the end of therapy the patient noted increased ability to breathe and smell through the right side of the nose, a pleasure he had not been able to enjoy for some time The change in the clinical and microscopic appearance of the tumor can only be described as dramatic (see Figs 1 and 2) The condensation of the collagen and maturity of the diminished number of blood vessels of these representative sections indicate the manner in which estrogen affects both the ground substance and vascular component (see Figs 3 and 4) Clinically, the tumor changed from a large red, firm mass with a somewhat boggy mucosal covering, to a mass which decreased about one half in size and increased in firmness to feel almost like cartilage Kodachrome studies of the pre and postoperative state could not show all the changes because of technical difficulties (see Slide 9) The patient was able to blow air through the right nostril—a function which was impossible prior to therapy

It had been decided prior to estrogen therapy that this tumor would be removed surgically regardless of the hormone response On Aug 11, under pentothal endotracheal anesthesia, a large piano wire snare was placed about the mass after having removed the right inferior turbinate

Electrocoagulation

High frequency or diathermal coagulation has the advantage over the simple hot-wire type of electric coagulation, in that it has penetration in depth. It seems logical to have used this type of therapy since these currents tend to burn deep and seal off blood vessels. The older literature, particularly that from the Continent, has numerous references for the use of electrocoagulation. In 1928 Roure[59] described his treatment of fibroma by this method. The French and Italian literature, particularly, contain numerous references for the use of this method,[60-65] however, in the past 15 or 20 years, the use of high-frequency coagulating current as a prime method of destroying the juvenile angiofibroma has fallen somewhat into disuse. This is in contrast to the frequent use of this modality in the treatment of small recurrences, in which case it is highly effective.

Sex Hormone Therapy

Boedts[66] from his experience with hormone therapy in the treatment of angiofibroma, described the use of estrone in a case and then followed it with progesterol. When the tumor did not cease its growth, X-ray therapy was then added, and finally the surgical removal of a large part of the tumor was accomplished. This is one of the earliest uses of hormone therapy. Unfortunately, there were no pre- or post-therapy slides which could be considered as demonstrating the effect of the hormone itself on the tumor. The final microscopic section showed considerable X-ray necrosis, together with various degrees of tissue reaction.

Apparently working on the premise that the tumor involutes, the hemorrhagic tendency decreases at maturity, and that it would be desirable to accelerate this maturity, Martin, Ehrlich, and Abels[12] decided to test the use of androgen therapy. Upon the administration of 25 mg. of testosterone propionate, they observed in one case a rapid disappearance of the tumor in the space of one month. In the two cases of the present series observed following androgen therapy, there was some involution, but it was not dramatic. A hypogenitalism syndrome with polycythemia and nasopharyngeal fibroma large, raw, bleeding surface rather than a smooth uninterrupted capsule.

Radium Therapy

In these highly vascular tumors, the insertion of a trocar for implantation of radon seeds can produce alarming hemorrhage; however, in small recurrences, this modality may afford satisfactory control. The dose and the distance should be so calculated as to produce a maximum sclerosing action with a minimum risk of radionecrosis. Figi[53] and Delavan[54] placed considerable reliance on radium therapy. Four seeds of 1.5 mc. each were placed 1 cm. apart by the author when seeding the left pterygomaxillary space of the patient in Case 3, making a total dosage of 6 mc. as recommended by Martin, Ehrlich, and Abels.[12] The subsequent involution was satisfactory. Forster[55] used two flat applicators of 25 mg. of radium each, with one millimeter lead filter for a period of seven hours. A slight improvement in the area was noted. He then used cautery and additional deep X-ray therapy because of the lateral extension of this tumor. Through the years, radium therapy has had many advocates,[11, 56-58] but the consensus is that it is most useful for smaller sized tumors and small recurrences.

X-ray Therapy

Because the angiomatous elements of many tumors are usually radiosensitive, X-ray therapy is undoubtedly somewhat helpful in reducing the vascularity of this tumor. The obliterative endarteritis of Roentgen-ray therapy will at least slow the growth of new angiomatous tissue and obliterate some of the vascular spaces of the more mature tissue. Probably little, if any effect is noted on the fibrous element. Doses of 1000 to 1500 r over each maxilla, or 2000 to 2500 r through the hard palate, have been given by Martin, Ehrlich, and Abels.[12]

Since the therapy is given before full facial growth is reached, some flattening of the facial bones from inhibition of their growth centers may occur. This might be minimized by cross-firing of the tumors through several portals, or rotation therapy.

increase in size of the now-existing spaces Figs 3 and 4 are high-powered photomicrographs of the pre- and post-treatment findings Note the marked difference in the tissues, it is hard to believe they are from the same patient These findings in the human individual confirm and corroborate for the first time the animal and experimental data which have been presented in detail in the preceding sections of this paper The clinical involution in this case was equally as dramatic (see Slides 8, 9, and 10) It is not meant to suggest that estrogen or any hormonal treatment is the complete answer to the problem for the angiofibroma, however, since it produces maturation in the connective tissue components of the tumor and appears to decrease the amount of bleeding, it is the author's opinion that this type of therapy is certainly worth trying as a supplement to other modalities, particularly prior to surgery

Surgical Therapy

There still exists a certain amount of controversy concerning the value of aggressive surgery for this tumor Martin, Ehrlich, and Abels[12] did not believe that aggressive treatment increased the number of cures, Figi and Davis[11] were of the opinion that it does increase the cure rate With the acknowledged limited experience in the four cases presented here, it would certainly seem that the earlier the tumors are detected and the smaller they are, the easier would be the possibility of complete removal In addition, the removal of the periosteum in the nasopharynx to which the tumor is attached definitely facilitates the excision of the tumor and probably results in a higher rate of cure Again, since these tumors are sometimes treated conservatively[23,69] and do not always cause death when untreated, it is necessary to temper courage with judgment if the tumor mass is of such size that removal would possibly jeopardize life The surgical removal of these tumors was noted in the historical section of this thesis to start in the Second Century and continue to the Twentieth Century Due to the fact that a number of approaches are physically limited, there have been cyclic repetitions or rediscoveries of these methods[70-77] These tumors have been removed transnasally, nasopharyngeally, transpalatelv, by re-was described by Redoglia,[67] indicating the obvious imbalance of the hormonal system in relation to the disease It is believed that in hormonal dysfunction an attempt should be made to correct this endocrine imbalance Androgen therapy shows significant histological changes, particularly in the vascular component and the ground substance Delarue, et al ,[68] noted a decrease in tumor size and a fibrinoid type of degeneration which they believed accounted for the clinical effects of testosterone The exact nature of this change is not completely discussed in terms of the metachromasia which they described in the ground substance

Hypogenitalism, which has been noted by many in association with this tumor, is probably due to the overactivity of the anterior pituitary which, in turn, has a suppressive effect on the genital growth Since the androgen output of the testes is not sufficient to inhibit the pituitary and create a normal balance between the two, a tilt in this axis persists It is in this type of endocrine configuration that the angiofibroma can potentially develop

Using a diametrically opposite rationale of endocrine therapy, this author felt that if the angiofibroma were exclusive in the male sex, the alteration of the androgen-estrogen pituitary axis by making the male more female might produce involution of the tumor Therapy of this type has its well-established parallel in the modern rationale of the treatment for carcinoma of the prostate by castration and high doses of estrogen Since the therapy appeared to be on a firm logical basis, it was decided to try it on the subsequent two cases In Case 3, it was used without previous biopsy, as a pilot observation to see whether involution occurred Dosages of 5 mg of Stilbesterol for one month, three times daily, were given The involution was sufficiently exciting to make sure that pretherapy biopsy would be taken in the future In Case 4, this was done and the involution was even more dramatic Preoperative microscopic sections (see Fig 1) show the immature connective tissue and the abundance of young vascular spaces Post-therapy microscopic sections (see Fig 2) revealed the maturation of the collagen and a considerable decrease in the number of vascular spaces, together with an increase in size of the now-existing spaces. Figs 3 and 4 are high-powered photomicrographs of the pre- and post-treatment findings. Note the marked difference in the tissues, it is hard to believe they are from the same patient. These findings in the human individual confirm and corroborate for the first time the animal and experimental data which have been presented in detail in the preceding sections of this paper. The clinical involution in this case was equally as dramatic (see Slides 8, 9, and 10). It is not meant to suggest that estrogen or any hormonal treatment is the complete answer to the problem for the angiofibroma, however, since it produces maturation in the connective tissue components of the tumor and appears to decrease the amount of bleeding, it is the author's opinion that this type of therapy is certainly worth trying as a supplement to other modalities, particularly prior to surgery.

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COMPLICATIONS

The most obvious complication is bleeding This may be of a severe nature, either before or after treatment Postoperative bleeding is not uncommon, particularly if the tumor has been incompletely removed With the advent of the modern blood bank system, the surgeon has an invaluable ally to help control excessive bleeding Infection is usually kept under control, particularly with modern antibiotic therapy Most secondary complications of infections are those incurred because of blockage of the drainage from the sphenoid and ethmoid sinuses Deformities of the face and palate occur[78] and can be minimized by planned surgical intervention The intracranial complications of this tumor are serious[79-81] and may occur before or after surgery Secondary pneumocephalus is, of course, not so serious as the potential meningitis With the drugs available which have a good passage of the blood brain barrier, control of these infections is easier

PHOTOGRAPHIC TECHNIQUE

Since photography of the nasopharynx is a procedure requiring a somewhat difficult technique, it is believed that the experience gained in these cases might be of help to those interested in photographing pathology in this area

1 Atropine sulphate, 0 4 mg, is injected subcutaneously one-half hour prior to starting photography for the average 18-year-old male

2 Pharynx and nasopharynx are sprayed with 2 per cent cocaine or 0 5 per cent pontocaine until pharyngeal anesthesia is adequate to prevent or minimize gag reflexes

3 In order to minimize the amount of contracture of the palatine musculature, with its subsequent closing off of the post-palatal space, 1 per cent xylocaine is injected about the posterior palatine foramen and, if necessary, in the lateral portion of the muculature of the soft palate itself

The patient is now ready to be photographed As can be noted by the 35 mm colored slides, the final pictures are a considerable improvement over the earlier ones The soft palate is drawn anteriorly and held in position by a self-retaining, multiple-hinged soft palate retractor[*]

An extra large special mirror with a 3- to 4-cm diameter and a somewhat malleable firm handle is placed in the pharynx facing the nasopharynx

A Kine Exacta camera with extension bellows and a ring electronic flash adapter was used Any single lens reflex camera which eliminates the parallax problem can be used The ring strob is a source of light originating about the camera lens to give powerful illumination without the parallax problem and ensuing shadows The shutter speed is 1/50 of a second and the aperture is determined by the film speed and watts/second output of the electronic flash A small attachment on the ring adapter gives enough light to permit focusing through the camera before the flash is tripped

DISCUSSION

With the advent of modern histochemical techniques, especially for the study of ground substances and connective tissue formation, there are new methods available for the study of many tumors, including juvenile angiofibroma The studies which have been presented in this thesis should be repeated and re-evaluated in all future cases, especially in the light of the newer staining techniques Delarue, et al ,[68] and Weisskopf and Burn[33] have shown variations in staining and the quantity of metachromasia demonstrated by these histochemical techniques applied to the nose and nasopharynx It becomes obvious that if these studies and investigations are to continue and be productive, pre- and post-treatment specimens should be obtained Pre-treatment, preoperative biopsies usually produce significant hemorrhage, and post-therapy operative removal produces hemorrhages of major proportion It is, therefore, felt that treatment can best be obtained at large clinics or university centers where adequate blood, selected anesthesia, and experience in handling these particular tumors are available These resources, plus a laboratory that is capable of and interested in further study of this interesting tumor, make an ideal combination

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[*] Manufactured by A. Klenk Co Maspeth Long Island N Y

The diversity of the microscopic appearance of this tumor from a thin, myxomatous stroma to a dense, collagenous one, or from a young, budding capillary to a mature blood vessel, might well produce considerable speculation as to the significance of the appearance of a single high-powered field It is, therefore, necessary to explore several sections of the tumor to select that area which appears representative Since both androgens and estrogens induce involution and both produce a similar type of response in the microscopic appearance of the tumor, it would appear that the basic physiologic pathology is a dysfunction of the pituitary and that either sex hormone so administered tends to inhibit some aspects of the pituitary function This, in turn, leads to the change in the ground substance and the involution of the tumor It is felt that the angiofibroma is basically a desmoplastic or connective tissue response of the nasopharyngeal periosteum to a hamartomatous ectopic nidus of vascular tissue, probably of the inferior turbinate type Its growth may start when the pituitary activity is first altered by the appearance or elaboration of the male sex hormone Since male and female hormones exist in both sexes, it is probably the alteration of the relationship or configuration between these hormones and the pituitary which permits this tumor to make its nearly exclusive nasopharyngeal appearance in the male

It is recognized that several unproven propositions exist herein, however, the tumor itself is rare, it is not possible to produce it in an animal, and embryologic studies of the nasopharynx to show the origin of the tumor would be nigh futile, since it is not possible to know which of the thousands of the nasopharynges might contain the vascular tissue in question Despite these unproven assumptions, the accumulation of clinical and experimental data on the diverse aspects of the problem appear to make the stated hypothesis a real possibility

It is not expected that estrogen therapy would obviate the necessity for surgery, but it can be expected to decrease the amount of bleeding and cause some degree of involution The use of female sex hormones to make a male more female carries with it some annoying physical and psychological reactions There is occasional enlargement of the breast and in some young men a distinct loss of libido These possibilities should be explained to the patient or the parents of a patient prior to instituting therapy The patient in Case 3 was a young married man who reacted to the libido-robbing medication and said, "Doctor, your pills are real strong but my wife was stronger" About three months after therapy was discontinued on this patient, his wife conceived and later delivered a healthy child A study of this case would seem to indicate that the sex life of the patient is only temporarily interrupted, and apparently no permanent damage is suffered by this modality of treatment A larger series of the effect of female hormones on the male would be most enlightening

Half of the cases reported here were located on the right, the other half on the left There appeared to be no predilection for the left side as is suggested by Acuña[32] This may be due to the difference in the number of cases reported

Another interesting observation is the fact that three out of the four cases reported herein were distinct redheads of various degrees Another patient recently seen in consultation by the author also had brown hair with a definite reddish cast to it *The significance of this observation is worthy of note but is indeterminate* Certainly these tumors occur in all ethnic and geographic groups, *as attested by the voluminous world literature reporting their isolated cases*, nonetheless, *it would be interesting for other observers to note* the skin and hair color in the appearance of future angiofibromas

SUMMARY AND CONCLUSION

Four cases of juvenile angiofibroma are presented Two of the patients were treated with androgen and two with estrogen Both hormones seem clinically to have an inhibiting effect to some extent on the tumor The effect of estrogen appears to be considerable, with microscopic proof presented with pre- and post-treatment slides to show the maturing effect of the female sex hormone It is hypothecated that since both hormones affect the maturity of this tumor, the mode of action is *via* the alteration of the pituitary activity The terminus of action is in the ground substance and connective tissue of the tumor It is proposed that this tumor is basically vascular and that the fibrous tissue component is a desmoplastic or connective tissue response to ectopic, sex-sensitive, vascular tissue like that found in the inferior turbinate

The treatment of these tumors with estrogen is not a substitute for other modalities of therapy but a supplement in an attempt to decrease the vascular bed and help to mature the tumor

Emphasis is placed on the necessity for future endocrine and histochemical studies of the ground substance to augment the basic understanding of this oncologic process

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ADENO-TONSILLECTOMY AND DEAFNESS IN CHILDREN[*][†]

BERNARD J MCMAHON, M D ,

Clayton, Mo

The indications for adeno-tonsillectomy have remained the same over the years, only the interpretations and applications of these indications have varied, according to the individual physician For that reason there has been an ebb and flow in the number of these operations performed, seasonally and otherwise

Unfortunately, there have been times when logic has been swayed by fetishism in the minds of certain extremists The most recent instance of this pseudo-hysteria is the persistance of the practice of not removing the tonsils and adenoid during certain months designated by the epidermiologists as the "polio season," regardless of the low numerical incidence of poliomyelitis cases at these times

As a consequence, we have encountered innumerable patients with histories of repeated otitis media who are in grave danger of a permanent loss of hearing, because the operations would not be performed during the summer months, and could not be performed during the months of acute respiratory infections, at which times there is a much greater risk of serious complications than there is during the statistical "polio season "

Among the many indications for the removal of the tonsils and adenoid in children, difficulty in hearing has probably received the least attention by the general practitioner and the pediatrician, unless it is so very marked that it is too obvious to be overlooked

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[*] Read at the Meeting of the Middle Section of the American Laryngological Rhinological and Otological Society St Louis Mo Jan 11 1959

[†] From the Clinics of Firmin Desloge Hospital and the Cardinal Glennon Memorial Hospital Department of Otolaryngology St Louis University School of Medicine through funds derived from the Stuever Memorial Fund of the Department The audiometric studies were performed by Mrs Nancy Schlenk and Miss Josephine Murphy

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which may be significant as trends toward progressive types of deafness They may be ignored in the evaluation of the audiograms by individuals who are not conversant with such minor deviations from the normal Such audiograms should be read and interpreted by otologists, if possible

It is disheartening to the otologist to encounter child after child of 2 to 5 years of age with enormous tonsils, and with naso-pharynx filled with adenoid tissue which completely blocks both choanae, who is compelled to endure this physiological impasse for the sole reason that it must wait until it reaches the age of 5 or 6 years to have the tonsils and adenoid removed "because this lymphoid tissue *must* have some function"

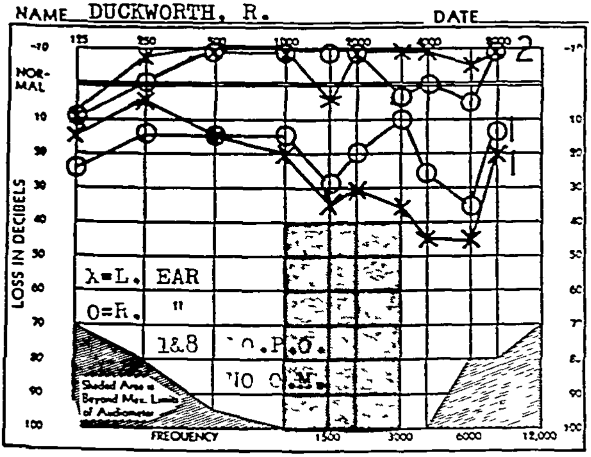


Fig 2 Age 7 hearing poor 4 years no otitis media (1) Pre-operative and (2) one and eight months post-operative audiograms X = Left ear O = Right ear

That this lymphoid tissue has a function we must all acknowledge, and we do recognize the fact that some strides have been made in efforts to determine this function, however, the absence of this tissue does not preclude the continued similar function of lymph glands and other lymphoid tissue throughout the body

Most investigators point up the fact that lymphoid tissue

Such remote consequences as inattention at home or in school, giving rise to situations of friction, social maladjustments, poor scholarship problems, or at times the more serious question of alleged personality changes of psychogenic origin in a child, are too frequently not recognized as possibly due to the inability of the child to hear adequately or to distinguish properly what is being said

The physician's approach to such a child is often a negative one in the light of the absence of a voluntary history by the patient, parent or teacher, of hearing difficulty Positive questioning will more frequently elicit the desired information, although in certain instances this is not obtained until revealed by the pure-tone audiogram and confirmed by the discrimination tests, if feasible

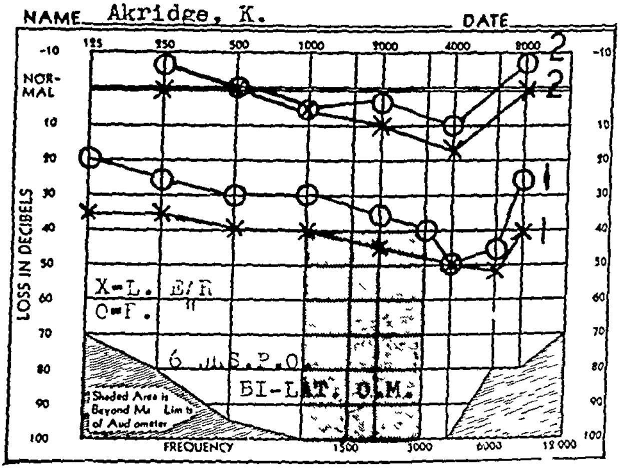


Fig 1 Age 9 hearing poor 3 years bilateral otitis media often (1) Pre-operative (2) six weeks post-operative audiograms X = Left ear O = Right ear

We realize the great value of the routine group audiometric tests being practiced in many of the public and parochial schools in recent years, in alerting teachers and parents to obvious hearing defects in school children, however, the circumstances under which these tests are conducted necessarily preclude the detection of less marked changes in hearing removal any more than we would any other tumor of similar local malignancy, regardless of the age of the patient

This state of local malignancy comprises the more or less complete obstruction of the nasal airway, thus causing the mechanical interference with the post-nasal drainage from the nasal sinuses, and with proper aeration of the eustachian tubes and middle ears, also, the harboring of infectious bacteria in the crypts of the adenoid and tonsil predisposes to extension of infection into the middle ears and paranasal sinuses

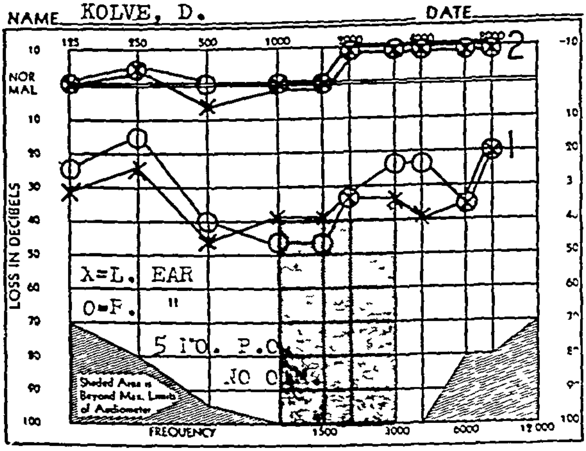


Fig 4 Age 6 years hearing poor 1 to 2 years (1) Pre-operative audiogram and (2) five months post-operative audiogram X = Left ear O = Right ear

This extension of infection into the middle ear may take place not only through the lumen of the short, straight and well open eustachian tube, but also through the subepithelial tissue of the mucosa of the tube and middle ear, causing the congestion and closure of the tube which isolates the infectious material in the middle ear

In discussing the removal of lymphoid tissue from the nasopharynx for the relief of deafness, one must necessarily consider irradiation of the nasopharynx with radium as a purposeful adjunct is somehow involved in the formation of antibodies Plasma cells, reticulo-endothelial cells and lymphocytes have been considered as stimulants or precursors of such antibodies Schenck[1] aptly *summarizes the plasma cell theory of antibody* formation as follows "The plasma cell appears to be the only cellular element in lymphoid tissue capable of synthesizing antibodies and Gammaglobulin Lymphoid tissue is the site of antibody formation and the lymphoid tissue of Waldeyer's *ring contains all of the cellular constituents essential for the* manufacture of humoral immune bodies Lymph *nodes and* other *lymphatic tissue appear to be the birthplace and grave-yard of lymphocytes as well as the source of antibodies*

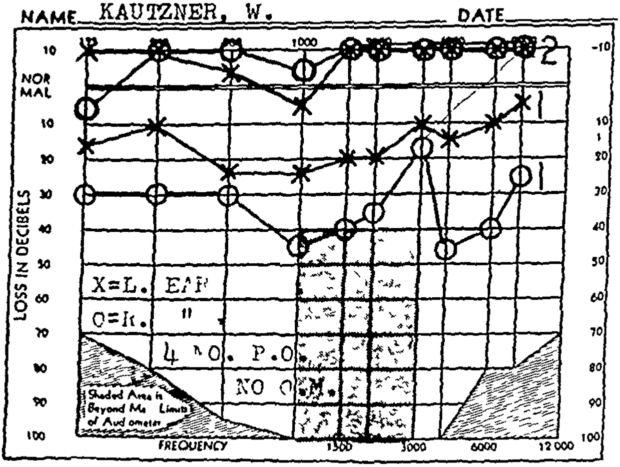
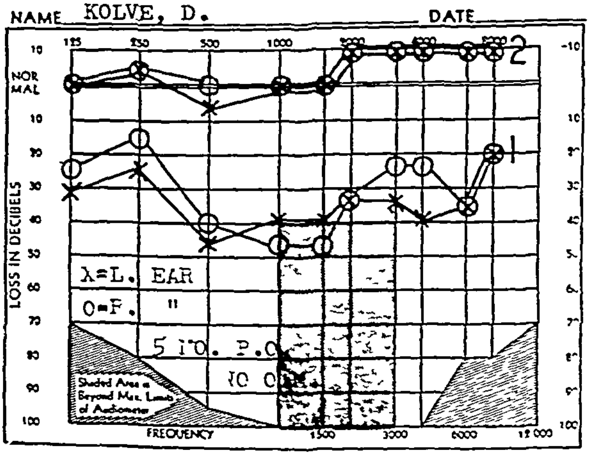


Fig 3 Age 7 hearing poor one year plus no otitis media (1) Pre-operative and (2) four months post-operative audiograms X = Left ear O = Right ear

"The strategic position and structural modifications of the lymphoid tissues of *Waldeyer's ring suggest* that the prime function of this tissue is the formation of antibodies and other Gammaglobulins", *nevertheless, however much we respect* and *wish to preserve* this *function, when the tonsils and* adenoid tissue become so greatly hypertrophied from repeated infections, allergic states or dietary maladjustments, that they assume the *proportions of tumors* with a verisimilitude of local malignancy, we would not be justified in deferring them removal any more than we would any other tumor of similar local malignancy, regardless of the age of the patient

This state of local malignancy comprises the more or less complete obstruction of the nasal airway, thus causing the mechanical interference with the post-nasal drainage from the nasal sinuses, and with proper aeration of the eustachian tubes and middle ears, also, the harboring of infectious bacteria in the crypts of the adenoid and tonsil predisposes to extension of infection into the middle ears and paranasal sinuses



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In discussing the removal of lymphoid tissue from the nasopharynx for the relief of deafness, one must necessarily consider irradiation of the nasopharynx with radium as a purposeful adjunct

This method, using 50 mgm of radium, shielded with 0 3 mm of monel metal, on an applicator for transnasal introduction into the nasopharynx, originated with Crowe at Johns Hopkins Hospital in 1924 [2]

In 1948 Crowe[3] reported favorably on this method in a paper read before the American Otological Society Following this and other more detailed reports, the nasopharyngeal radium applicator was used quite generally

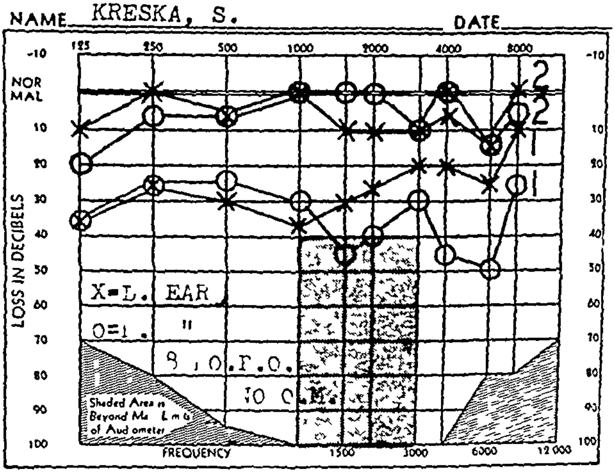

Fig 5 Age 6 years hearing poor for 3 years (1) Pre-operative audiogram and (2) eight months post-operative audiogram X = Left ear O = Right ear

In 1954, Bordley and Hardy[4] of Johns Hopkins reported at the meeting of the American Otological Society, a greater improvement in hearing in unoperated cases with irradiation, than in the non-irradiated cases, however, their optimism was not shared by the discussors

Among the objections raised were *1* Too large a dosage of radium for the safe toleration by the nasopharyngeal mucosa, and *2* the possible carcinogenic effect of this exposure to radium These comments I shall leave open to discussors in search of a possible explanation for the apparent lack of usage of this expedient in recent years

In 1956 Adams,[5] of Birmingham, England, reported up to 75 per cent improvements in hearing following the use of radium in non-benefited operated cases

In comparing the relatively prompt results obtained by thorough surgical removal of tonsils and adenoid, with the protracted questionable results claimed, in the quasi eradication of the adenoid and exuberant lymphoid tissue in the nasopharynx, using irradiation, the latter procedure seems to be an unjustifiable compromise when the importance of restoring hearing as soon as possible is the ideal objective

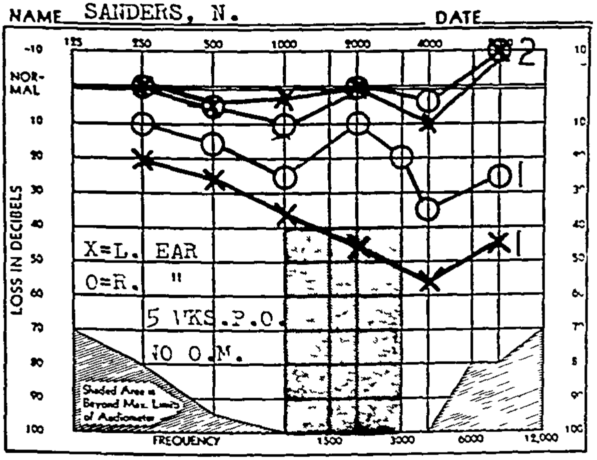

Fig 6 Age 9 years hearing poor 2 years plus (1) Pre-operative and (2) five weeks post-operative audiograms X = Left ear O = Right ear

This presentation is intended to stress the importance and the significance of the removal of hypertrophied tonsils and adenoid in patients with or without a complicating otitis media, who may have hearing defects as a result of infections of such tonsils and adenoid

The 86 children, between the ages of 6 and 13 years included in this study, were recommended for adeno-tonsillectomy for local and constitutional symptoms as well as for hearing defects Pre-operative audiometric and tuningfork studies were done within a few days of the operation and

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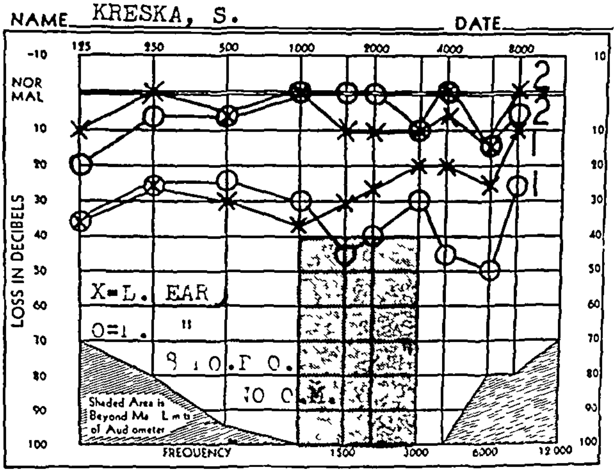

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SUMMARY

In a review of the incidence of poor hearing in 86 children who were undergoing adeno-tonsillectomy for reasons of health, we found that 45 (52.3 per cent) had normal hearing, audiometrically and clinically, and 41 (47.7 per cent) had poorer hearing. Among this 47.7 per cent, hearing was restored to normal in 63.4 per cent, and not improved in 36.6 per cent. The important factor in the non-improvement cases was probably attacks of otitis media, which occurred in 66.6 per cent over a period of several years.

Total—86		Otitis Media
	No. of Cases	No. of Cases
Audiogram normal	45 — 52.3 per cent	4 — 0.9 per cent
Audiogram not normal	41 — 47.7 per cent	18 — 43.9 per cent
Complaint poor hearing	21 — 51.2 per cent	10 — 47.6 per cent
Hearing improved	26 — 63.4 per cent	8 — 30.8 per cent
Not improved	15 — 36.6 per cent	10 — 66.6 per cent

The average age of patients at the time of operation was 7.8 years. The average length of time of the history of poorer hearing, with or without otitis media, was 2.4 years.

CONCLUSIONS

Judging by the definite improvement in hearing which followed adenoidectomy or adeno-tonsillectomy in children with poor hearing, with or without the complication of otitis media, we feel that it is advisable to perform this operation as soon as it is justified by the clinical conditions, regardless of the age of the patient. Procrastination may lead to irreparable damage to hearing.

repeated in four to several weeks postoperatively, according to the degree of cooperation by the parents. Discrimination audiograms were not done routinely, on account of the ages of the patients.

The history of poor hearing of varying degrees and lengths of time, as given by the mother or patient, occurred in 21 of the 86 patients (24.4 per cent). When this figure was allocated it was found to apply almost solely to the group of 41 patients (47.7 per cent), whose audiograms revealed hearing losses in one or both ears, an incidence of 51.2 per cent, in contrast to the remaining 45 patients (52.3 per cent) whose audiograms were normal, both pre- and post-operatively.

In this group of 41 patients the hearing improved to normal in 26 (63.4 per cent) within four weeks to eight months, as evidenced by several audiograms and by the absence of a subsequent history of diminished hearing.

In the group of 15 patients (36.6 per cent) whose hearing had not improved appreciably, there were four who had suffered a nerve or a mixed deafness. The remaining 11 were cases of conductive deafness, therefore, in the 37 cases of conductive deafness, there was improvement in 26 (70.3 per cent), and little or no improvement in 11 (29.7 per cent).

The incidence of one or several attacks of otitis media must always be considered as a possible deterrent to improvement in hearing, even though the adenoid and tonsils have been thoroughly removed. The history of otitis media seemed to have a more significant bearing on the lack of hearing improvement in the 15 cases. In this group, it occurred in 66.6 per cent, while in the 26 (70.3 per cent) definitely improved cases it occurred in only eight or 30.8 per cent.

When we consider the definite improvement in hearing which followed the adeno-tonsillectomies in a relatively short time we ask ourselves, should we not strive to help these children regain their hearing at an earlier age?

The average age of these children was 7.8 years at the time of their operations, and the average length of time that they were known to have had poor hearing was 2 4 years, during which time they had suffered many attacks of otitis media, and had probably experienced innumerable difficulties in adjusting at school and at home from their inability to keep in adequate contact with their environment during these most important formative years

SUMMARY

In a review of the incidence of poor hearing in 86 children who were undergoing adeno-tonsillectomy for reasons of health, we found that 45 (52 3 per cent) had normal hearing, audiometrically and clinically, and 41 (47 7 per cent) had poorer hearing Among this 47 7 per cent, hearing was restored to normal in 63 4 per cent, and not improved in 36 6 per cent The important factor in the non-improvement cases was probably attacks of otitis media, which occurred in 66 6 per cent over a period of several years

Total—86				Otitis Media
	No of Cases		No of Cases	
Audiogram normal	45	52 3 per cent	4	0 9 per cent
Audiogram not normal	41	47 7 per cent	18	43 9 per cent
Complaint poor hearing	21	51 2 per cent	10	47 6 per cent
Hearing improved	26	63 4 per cent	8	30 8 per cent
Not improved	15	36 6 per cent	10	66 6 per cent

The average age of patients at the time of operation was 7 8 years The average length of time of the history of poorer hearing, with or without otitis media, was 2 4 years

CONCLUSIONS

Judging by the definite improvement in hearing which followed adenoidectomy or adeno-tonsillectomy in children with poor hearing, with or without the complication of otitis media, we feel that it is advisable to perform this operation as soon as it is justified by the clinical conditions, regardless of the age of the patient Procrastination may lead to irreparable damage to hearing repeated in four to several weeks postoperatively, according to the degree of cooperation by the parents Discrimination audiograms were not done routinely, on account of the ages of the patients

The history of poor hearing of varying degrees and lengths of time, as given by the mother or patient, occurred in 21 of the 86 patients (24 4 per cent) When this figure was allocated it was found to apply almost solely to the group of 41 patients (47 7 per cent), whose audiograms revealed hearing losses in one or both ears, an incidence of 51 2 per cent, in contrast to the remaining 45 patients (52 3 per cent) whose audiograms were normal, both pre- and post-operatively

In this group of 41 patients the hearing improved to normal in 26 (63 4 per cent) within four weeks to eight months, as evidenced by several audiograms and by the absence of a subsequent history of diminished hearing

In the group of 15 patients (36 6 per cent) whose hearing had not improved appreciably, there were four who had suffered a nerve or a mixed deafness The remaining 11 were cases of conductive deafness, therefore, in the 37 cases of conductive deafness, there was improvement in 26 (70 3 per cent), and little or no improvement in 11 (29 7 per cent)

The incidence of one or several attacks of otitis media must always be considered as a possible deterrent to improvement in hearing, even though the adenoid and tonsils have been thoroughly removed The history of otitis media seemed to have a more significant bearing on the lack of hearing improvement in the 15 cases In this group, it occurred in 66 6 per cent, while in the 26 (70 3 per cent) definitely improved cases it occurred in only eight or 30 8 per cent

When we consider the definite improvement in hearing which followed the adeno-tonsillectomies in a relatively short time we ask ourselves, should we not strive to help these children regain their hearing at an earlier age?

The average age of these children was 7 8 years at the time

ENDOCRINE ASPECTS OF MENIERE'S DISEASE*

GEORGE E SHAMBAUGH, JR , M D ,

Chicago, Ill

Ménière's disease, or endolymphatic hydrops as we prefer to call it in view of its known pathology, is one of the most difficult therapeutic problems in otology Because of the fluctuations in hearing so characteristic of this condition the symptoms, at least in the earlier stages are reversible, and we cannot accept a nihilistic therapeutic attitude, nor can we advise destructive labyrinthine surgery except as a last resort, on the other hand, the medical treatment of this condition has been disappointing in many cases

The problem of hydrops is added to by the apparent increase in frequency of this type of hearing impairment Of the new patients seen in our office because of impaired hearing during the year 1958, 12 per cent were diagnosed as being the result of endolymphatic hydrops In addition to these new cases, we see a good many cases of hydrops following fenestration and stapes mobilization surgery In a study made in 1950,[1] 10 per cent of the fenestration patients followed in our office practice had developed definite symptoms of hydrops, beginning usually many months or years after a successful fenestration operation, with one or more of the four cardinal symptoms of hydrops, namely, an abrupt drop in hearing with fullness, roaring tinnitus and dizziness The fact that the hearing returned to its previous level and the other symptoms were relieved after administration of dilute histamine, was taken as evidence that the drop in hearing was due to hydrops and not to closure of the fenestra or nerve degeneration

I might mention that our routine medical management of hydrops[2] consists of specific therapy of any coincidental

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*Read at the Sixty-Second Annual Meeting of the American Laryngological Rhinological and Otological Society Inc Hot Springs Va March 11 1959

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It should be our responsibility as otolaryngologists to impress forcefully upon the general practitioner, the pediatrician, the parents, and the social service worker, the significance of the earliest complaint by a child, or the earliest impression of the parent of difficulty in hearing

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SIXTH INTERNATIONAL CONGRESS ON DISEASES OF THE CHEST

The Sixth International Congress on Diseases of the Chest will be held at the University of Vienna from August 29 to September 1, 1960

know that within the cytoplasm complex protein molecules are in a continuous process of being built up and torn down by means of enzymes operating through the mitochondria These enzymes which control protein catabolism and anabolism are produced by the cell itself When a new foreign protein is carried to the cell by the blood stream, there is produced within the cell a new specific enzyme to proteolyze this particular protein molecule and break it down into non-toxic amino acids These amino acids are then utilized as food to build new protein The newly formed enzyme is called *adapted or induced enzyme*, and once produced it remains in the cell ready to catabolize any new molecules of that particular foreign protein that may come along This, then, is the *normal* response of healthy living cells to the minute quantities of foreign protein that continually reach the cell via the blood stream

In the allergic individual a different course of events occurs Due to an inherited or acquired deficiency in enzyme production, or due to the presence of an enzyme inhibitor, the induced enzyme that arises when a foreign protein enters the cell is one that fails to produce all-or-none proteolysis to harmless non-toxic amino acids Instead, this abnormal enzyme produces *partial proteolysis* with the production of highly toxic compounds, including *histamine*, heparin, proteoses, serotoxin, acetylcholine, leukotaxine, pyrexin, necrosin, leukogenic factor, bradykinin, serotinin, and still other as yet unidentified compounds These toxic materials liberated within the cell each time more of this particular foreign protein enters the cell, produce the pathologic and clinical manifestations of the allergic reaction, with smooth muscle spasm, capillary dilatation and increased permeability, and edema

Thus we see that the *etiology* of the allergic state is the production of an abnormal type of enzyme This may be due to an inherited defect of enzyme production, or to enzyme inhibitors such as infections, antibiotics coal-tar products (salicylates, etc), or endocrine deficiency It is known that the action of thyroid hormone in particular, is closely related to the cytoplasmic mitochondria When there is a deficiency within the cell of thyroid hormone the formation of proteins allergic symptoms, a low salt diet, sometimes combined with the administration of ammonium chloride or potassium chloride, omission of smoking, and the administration of very dilute histamine according to the method of Hansel[3]. Histamine has been the most successful of these therapeutic agents, particularly in early cases where the hearing level was fluctuating markedly, and in the postoperative fenestration and stapes mobilization cases.[1]

I also call your attention to an interesting observation in cases of stapes mobilization that are revised. In a fair number of these there is an outpouring of perilymph, the moment the footplate is cracked, that far exceeds the amount of perilymph observed at the first operation. This suggests that the hydrops that occurs postoperatively may involve an increase in the amount of perilymph as well as in the amount of endolymph. The term labyrinthine hydrops may indeed be more appropriate than endolymphatic hydrops.

We became interested in the endocrine aspects of Ménière's disease through our interest in allergic problems and our more recent interest in the enzymatic concept of allergy. In the provocative little book by Z. Z. Godlowski entitled "Enzymatic Concept of Anaphylaxis and Allergy," published in 1953,[4] the rapid advances made in recent years in cellular physiology and protein metabolism are brought together in a new concept of the allergic state. This new concept explains many of the apparent contradictions and paradoxes of clinical allergy that were never explained by the antigen-antibody mechanism. Boiled down to the fewest possible words, the enzymatic concept of allergy is as follows.

The normal living cell is not at all the inert blob of cytoplasm that we are accustomed to seeing in the fixed stained microscopic slide. Rather, the living cell is in a state of constant and tremendous metabolic activity, vividly seen in phase-contrast cinematography of living cells in tissue culture. Around the nucleus we can see the mitochondria squirming and dancing, with hectic motion of granules and inclusions that appear and disappear. The cell membrane is in constant amoeboid undulatory movements, reaching out and drawing into itself nutrients from the surrounding fluid medium. We

Representative cases are the following:

Miss M.J.C., age six, complained of complete deafness in the left ear for one year, fluctuating hearing in the right ear for three months. Weekly injections of histamine 1-100,000,000 with drops of 1-10,000,000 dilution under the tongue twice daily, resulted in a remission in the fluctuating deafness in the good ear but each time the histamine was omitted the fluctuations recurred. A thyroid deficiency was suspected and confirmed by an endocrinologist. On desiccated thyroid the symptoms were relieved for eight years. She then returned because of a recurrence of the fluctuating deafness, despite large doses of thyroid extract. Endocrine evaluation revealed the hypometabolic syndrome. On tri-iodo-thyronine 100 mcgm twice daily, there was a complete remission in auditory symptoms as well as in the hypometabolic symptoms.

Mr. G.B., age 58, complained of progressive hearing loss in both ears for 12 years, with occasional attacks of vertigo. On the usual medical therapy including dilute histamine there was no improvement. Endocrine evaluation: hypometabolic syndrome, despite having taken desiccated thyroid for years. Therapy: tri-iodo-thyronine 5 mcgm t.i.d. resulted in a gradual improvement in hearing and a marked improvement in the ability to understand speech. Due to business pressure he resumed smoking and had a typical attack of vertigo but hearing remained improved.

Dr. L.A., was first seen at the age of 58 with complete deafness in the left ear for 25 years, and fluctuating hearing in the right ear for several years gradually increasing in severity. Medical therapy including dilute histamine of doubtful benefit. Endocrine evaluation: hypometabolic syndrome. Patient given bicillin for a chronic nasopharyngitis and tri-iodo-thyronine, increasing to 25 mcgm t.i.d. Within three days the hearing in the right ear returned to normal with cessation of roaring, dizziness and hearing fluctuation. After 18 months of complete absence of relapse he omitted tri-iodo-thyronine and after two weeks developed vertigo, tinnitus and a marked drop in hearing. Sedated B.M.R. now −20 in two tests whereas while on the tri-iodo-thyronine it had been normal. Resumed the medication 36 mcgm daily and within five days the hearing returned to normal and stabilized with disappearance of tinnitus and vertigo.

CONCLUSIONS

The enzymatic concept of allergy and related disorders offers a rational explanation for the etiology of endolymphatic hydrops, the increased production of endolymph being the result of abnormal enzymes in the epithelial cells of the stria vascularis. Toxic products of incomplete proteolysis due to these abnormal enzymes cause capillary dilatation and permeability in the stria vascularis. Dilute histamine injections probably serve to stimulate the production of the enzyme histaminase.

In 28 per cent of a small series of cases of hydrops that failed to respond to dilute histamine, correction of a deficiency suffers, and since enzymes are proteins, the formation of the normal type of all-or-none proteolytic enzyme is deficient

The relationship between endolymphatic hydrops and allergy has been noted by many authors, and is well documented in the very fine monograph by Henry L Williams[5] on Ménière's disease It is interesting that in our office force of 17 individuals, no less than six of us have had one or more typical episodes of endolymphatic hydrops All six of us are allergic to certain foods or inhalants, although our labyrinthine symptoms have not been associated with an allergic upset in most instances

In 53 cases of endolymphatic hydrops that failed to respond to the usual medical regime, including dilute histamine, the patient was referred for endocrine evaluation by the author of the Enzymatic Concept of Allergy[4] Of the 53 patients referred, 27 failed to return for adequate follow-up, while 36 followed the recommended therapy and returned for evaluation of the results Of these, 26 failed to show greater improvements in hearing or other symptoms than these same patients had experienced in spontaneous remissions and fluctuations, while in ten, or 28 per cent, the results of endocrine therapy were positive with definite improvement or complete relief in one or more of the cardinal symptoms Several of these cases were very dramatic, indeed, with results sufficiently definite to satisfy the most skeptical critic

In the great majority of cases the endocrine dysfunction was the hypometabolic syndrome of deficient utilization of thyroid hormone at the cellular level These patients have a normal protein-bound iodine level indicating normal production of thyroxin, but they have deficient utilization of thyroid hormone by tissue cells apparently due to inability of the cells to break down thyroxin to tri-iodo-thyronine The deficiency is evident in a lowered sedated basal metabolic rate, and in symptoms of hypothyroidism such as dry skin, thin hair, inability to lose weight, edema, constipation and fatigue The symptoms are not improved to administration of thyroxin or desiccated thyroid, but they are relieved by tri-iodo-thyronine

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TWO-FREQUENCY AUDITORY SCREENING A CLINICAL EVALUATION*

KINSEY M SIMONTON, M D ,
and
LEROY D HEDGECOCK, Ph D ,
(By Invitation),
Rochester, Minn

In 1957, House and Glorig[1] reported studies which showed that in 98 5 per cent of individuals, hearing loss of 4000 cycles per second was equal to or greater than that for lower frequencies As a result of this study they proposed a system of auditory screening that used the single frequency of 4000 cps Simple, self-contained battery-operated instruments were developed for this purpose These are available in single-frequency models that produce a tone of 4000 cps and in two-frequency models that provide tones of 4000 cps and 2000 cps Both instruments provide two intensity levels 35 db and 15 db

The purpose of single or two-frequency auditory screening is to provide a rapid method of determining those persons whose hearing is defective and who should have more extensive study The advantage of such a method is obvious when one contemplates testing large groups of individuals as in schools or industry Screening audiometry is also proposed for use by physicians other than otologists to discover those persons who have hearing problems and who should be referred to the otologist for further study

Our practice is one of general otorhinolaryngology The volume of work is such that pure-tone threshold audiometry for every patient is impractical Audiometric examination is done on those patients whose symptoms are related to the ear or hearing, and in certain groups being examined for in-

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of thyroid metabolism resulted in a greater improvement in symptoms than would probably have occurred in the normal fluctuations in these cases The usual deficiency was the condition known as the hypometabolic syndrome with normal P B I but lowered basal metabolic rate when this was taken after sedation In this condition desiccated thyroid is not effective, whereas tri-iodo-thyronine can relieve the hypometabolic symptoms

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3 Hansel, F K "Clinical Allergy" C V Mosby Co, St Louis, 1953

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5 Williams, H L "Meniere's Disease" Thomas & Co, Springfield, 1953

presented first at 35 db, then at 15 db The patient is instructed to report each time the tone is heard

The personnel who operate the auditory screeners have not had previous experience in testing of hearing They are carefully instructed in the operation of the instrument This is a very simple procedure which consists of turning the frequency selector to one of two positions for 4000 or 2000 cps The tone is presented by pressing one button for 35 db, another for 15 db An undesirable click is produced if the on-off button is depressed quickly, but can be avoided if the button is depressed slowly Possibility of error in operation is reduced to a minimum by the simplicity of the instrument

Audiograms were carried out by a qualified audiologist (L D H) and a technician who had had 15 years' experience in audiometry The tests were done on Maico E-2 audiometers that had been calibrated at the factory within the past year, and that had been further checked at threshold by comparison with a newly calibrated instrument, a group of normal-hearing individuals being used as test subjects All audiometry was done in sound-treated rooms in which the ambient noise level as determined by the General Radio Sound Level Meter was 32 db in one room and 38 db in the other, with the sound level meter set at the "A" response position

The records of 758 patients were available for review This was a selected group in which the majority complained of a hearing problem In order to evaluate the results of screening on normals, 90 additional patients who were unaware of a hearing problem were tested The auditory screen revealed no loss in 53 of these patients, while in 37 the 4000 cps tone was not heard at 15 db

The pure-tone threshold data were analyzed to determine the number of instances in which the pure-tone air-conduction threshold at 4000 cps was as great as, or greater than, the threshold at 500, 1000 and 2000 cps The threshold at one or all frequencies from 500 to 2000 cps was higher than the threshold at 4000 cps in 171 (20 2 per cent) of 848 audiograms studied The maximum by which the threshold for lower frequencies exceeded the threshold at 4000 cps was 5 db in dustry It is not done on patients whose symptoms involve only the nose or throat

Auditory screening of patients who would not normally have audiometric examination offers the advantage of detection of otherwise unrecognized hearing losses, and also provides a minimal record of hearing for future reference in the event the patient subsequently loses hearing Both are real advantages, which led to our decision to screen the hearing of each patient coming to our department

We selected a two-frequency, two-intensity screener with a single earphone This instrument provides tests at 4000 and 2000 cps at intensities of 35 and 15 db We consider screening at two frequencies more useful for our purpose than screening at a single frequency Four thousand cps has the advantage of demonstrating a high percentage of all hearing losses and of relative immunity to masking from the ambient noise of the average office This frequency alone is unduly selective when persons in the presbycusis age are tested Many persons have losses at 4000 cps whose hearing for speech is not significantly affected The addition of a screening test at 2000 cps gives information that aids in determining which patients have trouble hearing conversation The single-earphone instrument was selected for its simplicity and rapidity of operation The patient holds the earphone to his ear while the attendant operates the instrument

In our practice the screener is operated by the attendant who shows the patient to the examining room The test is done in the examining room with the door closed The rooms have no sound conditioning, although the sound of feet is minimized by cork flooring The most prominent sound within the room is that of air flowing through the ventilating ducts Outside the room are sounds arising from conversation of patients in the corridor and intermittently from instruments being cleaned and placed in the sterilizer Outside windows are sealed The level of ambient noise in the room measured with the General Radio Sound Level Meter set at the "A" position approximates 42 db but peaks to 60 db at times Each ear is tested, first at 4000 cps, then at 2000 cps The tone is

The findings of the auditory screening were confirmed by the pure-tone threshold audiogram in 473, or 55 8 per cent, of the 848 patients Errors occurred in 375 instances The screen indicated better hearing than the audiometric threshold in 115 instances, less hearing in 243 instances Multiple errors of similar class (better or worse) appeared on 95 cards Crossed errors (screen both better and worse) appeared on 17 cards Where multiple errors occurred the card was classified according to the error of greatest magnitude

TABLE IV

Instances in Which Screen Showed More Hearing Than Audiometer

	Number
By + 5 db	48
+10 db	23
+15 db or more	44
Significant errors (10 db or more)	67 (7 9%)

TABLE V

Instances in Which Screen Showed Less Hearing Than Audiometer

	Number
Screen not heard at level heard on audiometer	80
By − 5 db	70
−10 db	60
−15 db or more	33
Significant errors (10 db or more)	93 (11 0%)

Variations of plus or minus 5 db are generally considered to be within normal limits of error in audiometry Errors of 10 db or more occurred in 160 instances (18 9 per cent) In 67 patients (7 9 per cent) the screen showed more hearing than the audiogram (see Table IV) The magnitude of the error ranged to 85 db In this instance, a patient whose audiogram showed no hearing in one ear was reported as hearing 15 db on the screen test In 93 patients (11 0 per cent) the screen showed less hearing than the audiogram (see Table V) The maximum error in this direction was 20 db

COMMENT

Study of this series of audiograms indicates that a single-

TABLE I

Audiograms in Which the Threshold at 500, 1000 or 2000 cps Exceeded the Threshold at 4000 cps Among 848 Audiograms

	Number	Per cent
Total	171	20.2
Exceeded by		
5 db	69	8.2
10 db	40	4.7
15 db	26	3.1
20 db or more	36	4.2
Significant errors (10 db or more)	102	12.0

TABLE II

Instances in Which Screen Showed Normal Hearing (93 Patients)

Screen and Audiometer	Number
Agreed	89
Disagreed	4
By + 5 db	3
+15 db	1

TABLE III

Screen Showed Loss of 15 db at 4000 cps (67 Patients)

Screen and Audiometer	Number
Agreed	24
Disagreed	43
Screen not heard at level heard on audiometer	10
By − 5 db*	13
−10 db	11
−15 db	5
+ 5 db	1
+15 db	3

*− = screen showed poorer hearing than audiometer, + = screen showed better hearing than audiometer

69 instances, 10 db in 40, 15 db in 26, and 20 db or more in 36. Differences of 5 db can be considered within the limit of error in audiometry. Differences greater than 5 db are considered significant. Differences of 10 db or more were observed in 102, or 12 per cent, of the audiograms studied (see Table I).

The auditory screen showed no loss in 93 of the 848 patients. The audiogram agreed with this finding in 89 (see Table II). The screen showed loss of 15 db for the tone of 4000 cps in 67 patients. The audiometric threshold confirmed the screen in 24 instances (see Table III).

The findings of the auditory screening were confirmed by the pure-tone threshold audiogram in 473, or 55.8 per cent, of the 848 patients. Errors occurred in 375 instances. The screen indicated better hearing than the audiometric threshold in 115 instances, less hearing in 243 instances. Multiple errors of similar class (better or worse) appeared on 95 cards. Crossed errors (screen both better and worse) appeared on 17 cards. Where multiple errors occurred the card was classified according to the error of greatest magnitude.

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10 db	40	4 7
15 db	26	3 1
20 db or more	36	4 2
Significant errors (10 db or more)	102	12 0

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Screen and Audiometer		Number
Agreed		89
Disagreed		4
By + 5 db	3	
+15 db	1	

TABLE III

Screen Showed Loss of 15 db at 4000 cps (67 Patients)

Screen and Audiometer		Number
Agreed		24
Disagreed		43
Screen not heard at level heard on audiometer	10	
By − 5 db*	13	
−10 db	11	
−15 db	5	
+ 5 db	1	
+15 db	3	

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COMMENT

Study of this series of audiograms indicates that a single-

frequency screen at 4000 cps is not a valid index of maximal loss The difference between our results and those reported by House and Glorig is explained in part by the relatively high proportion of patients with conductive lesions and end-organ lesions among those tested

Comparison of the results of auditory screening and pure-tone threshold audiometry done under the conditions described reveals a high proportion of error Repeated comparison of the screeners and the audiometers by loudness-balance tests using normal ears failed to reveal significant differences in the calibration of the instruments This, plus the fact that the screening test showed both more and less hearing than the threshold tests, suggests that the discrepancies resulted from errors of technique and of recording The threshold tests were done by experienced personnel using well-standardized techniques The screening tests were done by inexperienced personnel who had been instructed in use of the instrument but who lacked the experience necessary to question the results of their own tests We assume that the errors are principally in the results of the screening tests

Possible sources of error in which the screen shows more hearing than the threshold test are a click present when the on-off button of the screener is depressed and response of the patient to the examiner's voice when asked "Do you hear now?" The first error can be reduced by care in depressing the button and by occluding the ear not being tested The second can be avoided by better instruction of the operator in the technique of hearing tests Possible sources of error in which the screen shows less hearing than the threshold test are masking by ambient noise, which should have little effect at 4000 cps, improper positioning of the earphone by the patient, and poor instruction of the patient in the nature of the test

Use of a screener equipped with binaural earphones would reduce errors due to ambient noise or clicks in the instrument Adjustment of the head set would require more time, and the addition of another switch to the screener would add to the chance of designating the wrong ear when the results are recorded

Our experience indicates that auditory screening is not a procedure that can be accurately performed by inexperienced personnel after minimal instruction. The instructions given to members of our office staff in the use of the screener were deemed adequate. In addition, as errors were noted they were often called to the attention of the attendant operating the screener. Many times, obvious errors were rechecked by the consultant in the presence of the attendant and different results noted. Despite these precautions, differences of 10 db or more between results of the screen and threshold audiometry were noted in 18.9 per cent of the records studied. This study suggests that the operator of an auditory screener must have both adequate instruction and experience if the results of the test are to be reliable. On the basis of our experience there is doubt as to the value of this procedure in situations in which the operators of the screening instruments fail to receive abundant experience as well as some objective evaluation of the results obtained.

SUMMARY AND CONCLUSIONS

The results of two-frequency, two-intensity auditory screening were compared with the pure-tone, air-conduction threshold audiograms in 848 patients. Significant discrepancies appeared in 18.9 per cent of the records. It is believed that the majority of errors resulted from poor technique in the operation of the auditory screeners and in the recording of results.

ADDENDUM

Continued comparison of the results of auditory screening with the results of pure-tone threshold audiometry has shown moderate improvement in the correlation between the two tests. Four hundred and sixty records were reviewed. Errors of 10 db or more were noted in 49 (10.7 per cent). The highest incidence of error occurs in tests done by assistants who are temporarily assigned to the department.

REFERENCE

1. House, H. P., and Glorig, A.: A New Concept of Auditory Screening. The Laryngoscope, 67:661, July, 1957.

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Use of a screener equipped with binaural earphones would reduce errors due to ambient noise or clicks in the instrument Adjustment of the head set would require more time, and the addition of another switch to the screener would add to the chance of designating the wrong ear when the results are recorded pathological entity and separated it from branchiogenic cysts They suggested the tumor arose from heterotopic salivary gland tissue found in lymph nodes of the parotid region

In 1929, Warthin[32] made the first report in American literature, he described two cases in over 700 parotid tumors He thought the tumor resembled the Eustachian tube in architecture and postulated its origin in a displaced anlage of the Eustachian tube He proposed that the tumor be called papillary cystadenoma lymphomatosum, however, his name became associated with the lesion, and in this country it is commonly known as Warthin's tumor

TABLE I

Various Terms for Cystadenoma Lymphomatosum *

1 Congenital epithelial cysts
2 Branchial cyst of the parotid
3 Cystadenoma of the parotid
4 Papillary cystadenoma in lymph node
5 Papillary intralymphonodular cystadenoma
6 Branchiogenic adenoma of neck
7 Branchiogenic papillary cystadenolymphoma
8 Branchioma
9 Epitheliolymphoid tumor of parotid
10 Lymphoglandular cystoma
11 Papillary cystadenoma with lymphoid supporting tissue
12 Cystic papillary adenoma
13 Papillary cystadenolymphoma
14 Kyste Amygdaloide
15 Tumeur amygdaloide
16 Polykstiques cystadenolympho ma parotids
17 Adenoma branchiogenes cylindrocellulare cystium
18 Papillary cystadenoma lymphomatosum
19 Papillary cystadenoma
20 Onkocytoma.
21 Orbital inclusion cyst
22 Adenolymphoma
23 Adenocysticum lymphomatosum
24 Warthin s tumor

*Chaudry A P and Gorlin R J Papillary Cystadenoma Lymphomatosum (Adenolymphoma) Amer Jour Surg 95 923 1958

Since that time a multiplicity of terms have been used to describe the lesion (see Table I) Each name reflects the author's opinion of the histogenesis of the tumor or tends to stress one or the other of its elements This has made the subject appear complex and has led to some difficulties in classification of parotid tumors

Grossly, the tumor is round or oval Its surface has a slightly lobulated appearance produced by the cysts which may appear translucent through the thin, fibrous capsule It is usually located in the lower part of the superficial portion

PAPILLARY CYSTADENOMA LYMPHOMATOSUM OF THE PAROTID GLAND *

JOHN F DALY, M D ,
New York, N Y

INTRODUCTION

Non-tender swellings in the parotid region are usually caused by neoplasms About 60 per cent of these are benign mixed tumors, another 30 per cent are malignancies arising in mixed tumors or as primary growths The third common tumor is the papillary cystadenoma lymphomatosum It was once considered rare, however, it accounts for about five per cent of all parotid tumors[14] and over 367 cases have been reported in the literature[7] Examples of this tumor can be found in the files of most surgical clinics

The tumor is composed of epithelial and lymphoid tissue This feature is common to another lesion of the salivary gland from which it must be clearly distinguished, namely, Mikulicz's disease (the benign lymphoepithelial lesion) It is common practice to discuss these lesions together under the single designation, adenolymphoma, however, they are two distinct entities, both clinically and pathologically This report is primarily concerned with the papillary cystadenoma lymphomatosum and will discuss Mikulicz's disease later in the differential diagnosis

Hildebrand,[17] in 1895, was the first to describe the lesion In a study of lateral cervical cysts and fistulas, he included a description of a lesion composed of both lymphoid and epithelial elements He considered this a variation of a branchiogenic cyst, and suggested that it probably was derived from heterotopic entoderm

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TABLE I

Various Terms for Cystadenoma Lymphomatosum *

1 Congenital epithelial cysts
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7 Branchiogenic papillary cystadenolymphoma
8 Branchioma
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10 Lymphoglandular cystoma
11 Papillary cystadenoma with lymphoid supporting tissue
12 Cystic papillary adenoma
13 Papillary cystadenolymphoma
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15 Tumeur amygdaloide
16 Polykystiques cystadenolymphoma parotids
17 Adenoma branchiogenes cylindrocellulare cystium
18 Papillary cystadenoma lymphomatosum
19 Papillary cystadenoma
20 Onkocytoma
21 Orbital inclusion cyst
22 Adenolymphoma
23 Adenocysticum lymphomatosum
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Since that time a multiplicity of terms have been used to describe the lesion (see Table I) Each name reflects the author's opinion of the histogenesis of the tumor or tends to stress one or the other of its elements This has made the subject appear complex and has led to some difficulties in classification of parotid tumors

Grossly, the tumor is round or oval Its surface has a slightly lobulated appearance produced by the cysts which may appear translucent through the thin, fibrous capsule It is usually located in the lower part of the superficial portion

PAPILLARY CYSTADENOMA LYMPHOMATOSUM OF THE PAROTID GLAND*

JOHN F. DALY, M.D.,

New York, N. Y.

INTRODUCTION

Non-tender swellings in the parotid region are usually caused by neoplasms. About 60 per cent of these are benign mixed tumors, another 30 per cent are malignancies arising in mixed tumors or as primary growths. The third common tumor is the papillary cystadenoma lymphomatosum. It was once considered rare, however, it accounts for about five per cent of all parotid tumors[14] and over 367 cases have been reported in the literature.[7] Examples of this tumor can be found in the files of most surgical clinics.

The tumor is composed of epithelial and lymphoid tissue. This feature is common to another lesion of the salivary gland from which it must be clearly distinguished, namely, Mikulicz's disease (the benign lymphoepithelial lesion). It is common practice to discuss these lesions together under the single designation, adenolymphoma, however, they are two distinct entities, both clinically and pathologically. This report is primarily concerned with the papillary cystadenoma lymphomatosum and will discuss Mikulicz's disease later in the differential diagnosis.

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Grossly, the tumor is round or oval. Its surface has a slightly lobulated appearance produced by the cysts which may appear translucent through the thin, fibrous capsule. It is usually located in the lower part of the superficial portion of the gland, it may be extracapsular or lie in the substance of the gland In the deep portion of the gland, it displaces the normal tissue It may be unicentric or multicentric Its cut surface reveals a pink-grey tissue with cystic spaces filled with brown or straw-colored, gelatinous fluid

Microscopically, the tumor has an easily recognized appearance given to it by the two types of tissue which compose it An epithelial layer lines the cystic spaces and projects into the lumen as multiple branching papillas Cells of the epithelial layer are arranged in two rows The inner cells are tall, columnar with oxyphilic cytoplasm Their nuclei are arranged in an orderly fashion at the luminal end of the cells They are not ciliated as Warthin thought The outer or basal cells are polygonal and rest on a distinct basement membrane which separates them from the lymphoid stroma The cystic spaces may be filled with branching papillas, or contain a granular material produced by the secreting epithelium and by debris of extruded mature cells

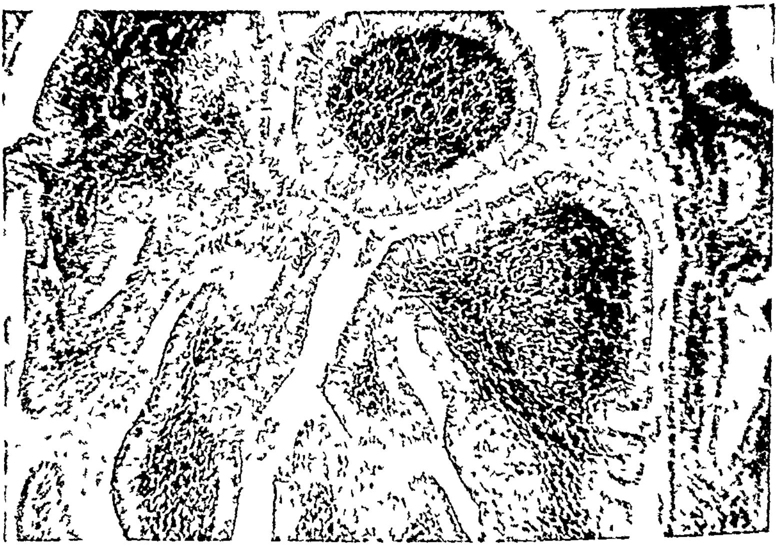

Fig 1 Papillary cystadenoma lymphomatosum showing typical arrangement of papillae

Lymphoid tissue forms the supporting stroma of the tumor and extends into the core of the papillae Germinal centers are prominent In some cases the essential architecture of the lymph node is preserved and the capsule, lymph sinuses and cortex can be identified [3,31]

HISTOGENESIS

The presence of both epithelial and lymphoid elements in the tumor, plus its occurrence limited to the parotid region, has stimulated much speculation about its origin The tumor has been thought to arise from *1* displaced pharyngeal entoderm,[1-32] *2* Eustachian tube anlage,[32] *3* branchiogenic cysts or fistulas,[1-29] *4* aberrant salivary gland tissue in lymph nodes,[1] *5* ectopic tonsillar tissue,[5 19] *6* the orbital inclusion body of Chievitz,[20] and *7* onkocytes found in salivary glands of adults [15 18]

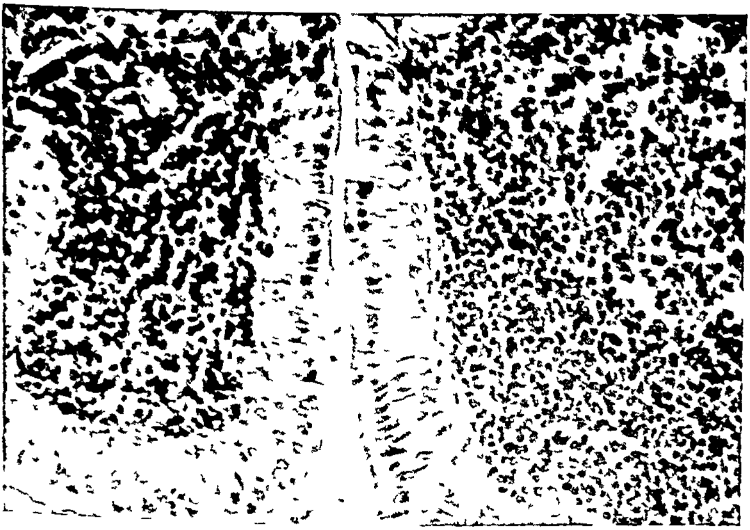

Fig 2 Papillary cystadenoma lymphomatosum showing epithelial layer and lymphoid stroma

The branchiogenic theory of origin is not supported by any similarity between the epithelium of the tumor and that of branchiogenic cysts or fistulas Branchiogenic cysts and fistulas are lined by stratified squamous epithelium or by pseudostratified ciliated columnar epithelium, alone or in combination Thompson and Bryant[31] could find no similarities in staining qualities or in nuclear arrangements between the branchiogenic epithelium and that of Warthin's tumor

Warthin believed the tumor represented a developmental disturbance of the Eustachian tube anlage which later became neoplastic His opinion was based on the misconception that the epithelium of the tumor was ciliated like that of the Eustachian tube It is agreed by most investigators that the cilia which Warthin described were artifacts

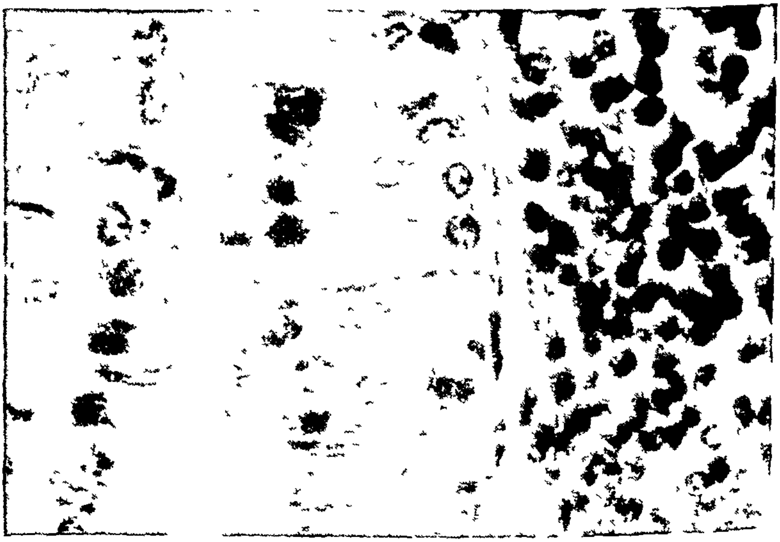

Fig 3 Papillary cystadenoma lymphomatosum showing columnar cells basal cells and basement membrane

The onkocytic theory of origin was proposed by Hamperl[15] The onkocytes are cells which characteristically appear in salivary glands after the age of 30 They have an oxyphilic finely granular cytoplasm and nuclei rich in chromatin The tumor was thought to have its origin in these cells The theory does not explain the tumors which arise before the appearance of onkocytes in the young age group, furthermore, onkocytes have been found in other locations, but Warthin's tumors occur only in the parotid region

The heterotopic salivary gland theory was proposed by Albrecht and Arzt[1] and has gained the widest acceptance There are many facts which tend to support it *1* during embryonic development, the parotid gland, unlike the submaxillary, does not have a difinite capsule separating it from other tissues in the area, hence, some glandular tissue may become separated from the developing gland or become enmeshed in the lymphoid tissue developing in the same area, *2* salivary gland tissue has been found frequently in the lymph nodes of the parotid region, both in fetuses and in adults,[13 31] *3* tumor is found only in the parotid and periparotid region [22] *4* the lymphoid stroma of the tumor is not an infiltrate, but retains the normal characteristics of a lymph node, this indicates that the tumor arises within the lymph node,[7] and *5* the cells of the papillary layer are similar to cells found lining the ducts of normal parotids [31]

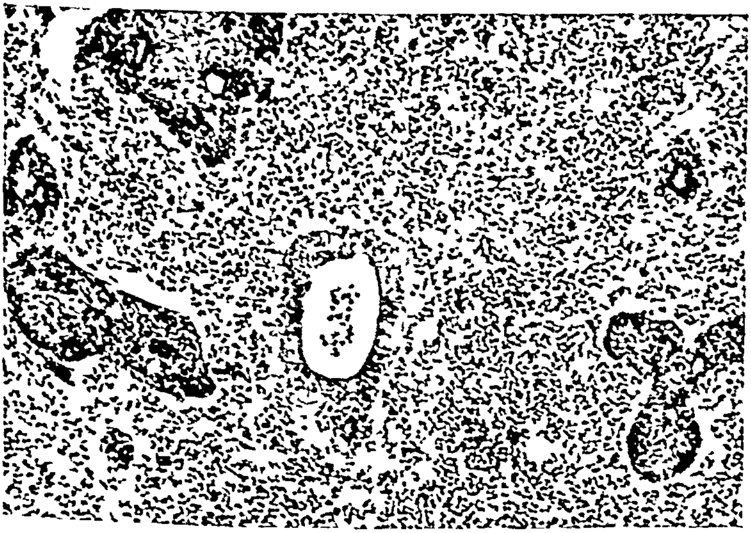

Fig 4 Benign lymphoepithelial lesion (Mikulicz s Disease) showing epimyoepithelial islands and lymphoid stroma

These observations support the theory of Albrecht and Arzt that the tumor represents a true neoplasm developing from pseudostratified ciliated columnar epithelium, alone or in combination Thompson and Bryant[31] could find no similarities in staining qualities or in nuclear arrangements between the branchiogenic epithelium and that of Warthin's tumor

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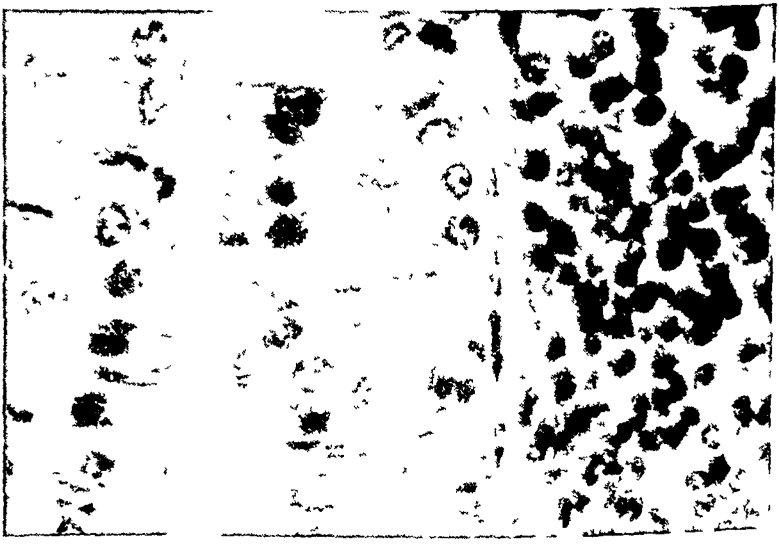

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When the tumor presents in the neck, it is located along the anterior border of the sternomastoid muscle In this location, it is in contact with the posterior border of the submaxillary gland This finding has led some authors to conclude that the tumor arises from the submaxillary gland Martin and Ehrlich[22] believe that this is an error due to failure to realize that a tumor arising from the tail of the parotid will come in contact with the submaxillary gland All of their 25 cases arose or were connected with the parotid alone

DIAGNOSIS

A clinical diagnosis of this tumor is rarely made before histological examination It is usually diagnosed as a mixed tumor of the parotid or as a branchiogenic cyst when it presents in the neck

Twenty-five cases of papillary cystadenoma lymphomatosum were found in the pathology files of the University Hospital and an additional six cases at Bellevue Hospital Twenty-eight cases were males, and three were females All patients were between 40 and 60 years old In one patient both parotid glands were involved

DIFFERENTIAL DIAGNOSIS

The tumor must be distinguished from *1* mixed tumors of the parotid, *2* malignancies, *3* branchiogenic cysts, *4* lymphomas, *5* leukemia, *6* metastatic carcinoma from the undiscovered primary in the oral or pharyngeal cavities, and *7* Mikulicz's disease The means available for diagnosis are sialography and aspiration biopsy

Sialography in Warthin's tumor shows displacement of the duct system when the tumor is within the parotid, and no change in the ductual pattern when it is extracapsular,[4] thus the sialogram does not distinguish it from other encapsulated lesions, however, in Mikulicz's disease, where the pathology is in the ductal system, sialography is helpful in diagnosis, especially when distortion and sialectasis can be demonstrated the ductal epithelium of aberrant salivary gland tissue trapped in lymph nodes of the parotid region.

CLINICAL COURSE

The tumor usually presents as a non-tender swelling located in front of the lobe of the ear or just behind the angle of the jaw, or it may be located in the upper part of the neck. The patient rarely has any complaint other than facial disfigurement. The tumor is slow growing and is usually present months or even years before the patient seeks medical advice. Eighty per cent of the tumors occur in the 40 to 70 year age group.[6] Less than 10 per cent are under 10. The youngest recorded case in the literature is a two-and-a-half year old child. Males are affected five times more than females. Bilateral tumors are not common, only 11 cases have been reported.[11]

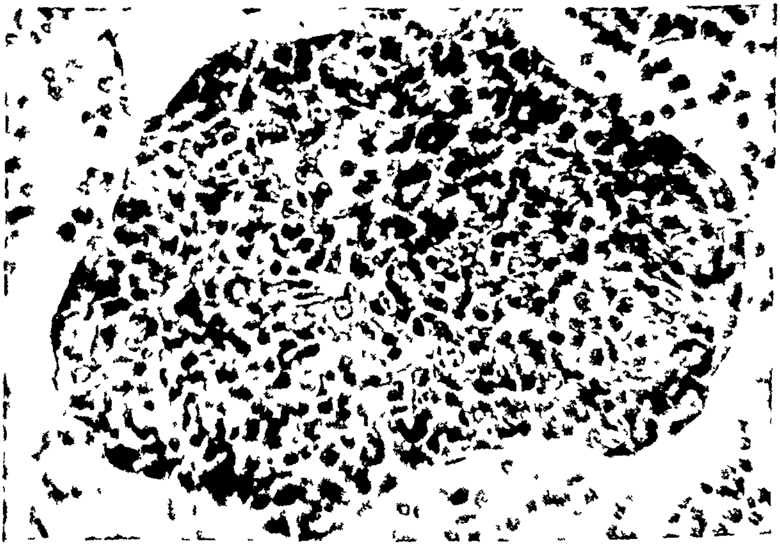

Fig. 6. Benign lymphoepithelial lesion showing epimyoepithelial island.

To palpation, the tumor is a smooth, round or oval mass which is usually moveable and is moderately firm to cystic in consistency.

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Aspiration biopsy may be used to establish a diagnosis prior to surgery. If the aspirated material contains the papillary layer, the diagnosis is not difficult, however, if only lymphoid tissue is obtained in the aspiration, the diagnosis cannot be made. Martin and Ehrlich[22] reported 12 positive biopsies in 18 cases in which they had done aspiration biopsies. Because there is some danger of spilling cells from a mixed tumor during an aspiration biopsy, a frozen section at the time of surgery is preferred.

Papillary cystadenoma lymphomatosum should be distinguished from "the benign lymphoepithelial lesion"[13] or Mikulicz's disease. In 1888, Mikulicz[23] described a case of a young man with enlargement of the lacrymal and salivary glands. Mikulicz insisted that the lacrymal gland involvement was an essential part of the condition. Morgan and Castleman[2] have shown that the lesion may not involve the lacrymal gland, but may be limited to one or two salivary glands.

Mikulicz's disease occurs predominantly in women in the fifth and sixth decades. Eighty-three per cent of Morgan and Castleman's cases were females.

Histologically, the tumor is composed of lymphoid tissue in which are found epimyoepithelial islands. The epimyoepithelial islands are produced by intraductal proliferation of epithelial and myoepithelial cells. The lymphoid stroma appears as an infiltrate which replaces the normal gland structure. Germinal centers are few.

The etiology and pathogenesis of the disease are obscure. Most investigators believe it is a reactive or inflammatory disease. Bauer[2] is convinced that it is a neoplasm and bases this conclusion on the active new growth of the epithelial cells in recurrences.

Morgan[24] has suggested that Mikulicz's disease is related to Sjogren's syndrome (keratoconjunctivitis sicca, bucco-pharyngo-laryngitis sicca, swelling of the salivary gland and polyarthritis) and that the histological picture is similar in both diseases.

Warthin's tumor and Mikulicz's disease have several features which may be contrasted (see Table II)

TREATMENT

Treatment of papillary cystadenoma lymphomatosum is surgical excision Since the majority of tumors are found in the superficial portion of the gland, they can be removed without disturbing the facial nerve When the lesion is multicentric or is located in the substance of the gland, the modern principles of parotid surgery should be followed The facial nerve is located as it enters the posterior aspect of the parotid, and the entire superficial portion of the gland, with the tumor, is removed without injury to the facial or its branches When the tumor is located in the deep portion of the gland, the facial nerve is gently retracted while the deep portion of the gland is dissected from the nerve and the surrounding structures There is no justification for sacrifice of the facial nerve or its branches

TABLE II

Papillary Cystadenoma Lymphomatosum Warthin's Tumor	Benign Lymphoepithelial Lesion Mikulicz's Disease
1 Neoplastic	1 Inflammatory reactive, neoplastic?
2 Males predominant—5 to 1	2 Females predominant—4 to 1
3 Age—40 to 70	3 Age—5th to 6th decade
4 Parotid only	4 Salivary and lachrymal glands
5 No symptoms	5 Dryness of mouth and pharynx
6 Sialogram — displacement of ducts	6 Distortion and sialectasis
7 Aspiration biopsy—positive 2/3 of cases	7 Not diagnostic
8 Histology—papillary, epithelial layer Lymphoid tissue with germinal centers	8 Epi myoepithelial islands Lymphocytic infiltration
9 Treatment—surgery	9 Treatment—surgery and/or radiation

The prognosis of this tumor is good There are no authentic cases of malignancy that have withstood critical analysis Recurrences are less than 10 per cent and are due to incomplete removal Radiation therapy has no effect on the tumor

The treatment of Mikulicz's disease is either surgery or radiation therapy. Godwin[13] advocates surgery followed by radiation. In bilateral cases after surgical excision of one side, he advocates radiation therapy for the opposite side, instead of surgical excision. The response to radiation is good and recurrences are less than in surgery.[26] There were seven cases of benign lymphoepithelial lesion (Mikulicz's disease) found in the pathology files at University and Bellevue Hospitals, five of these were females, two were males. All were treated surgically.

CONCLUSIONS

1 Papillary cystadenoma lymphomatosum is the third common neoplasm of the parotid, it accounts for about five per cent of all parotid tumors.

2 It is a benign neoplasm composed of epithelial and lymphoid elements, its histogenesis, while not certain, probably is from salivary gland rests found in lymph nodes of the parotid region.

3 Clinically, it is indistinguishable from other benign, nontender parotid swellings. Positive diagnosis depends upon histological examination.

4 Treatment of papillary cystadenoma lymphomatosum is surgical. Radiation has no effect on the tumor.

5 Benign lymphoepithelial lesion, or Mikulicz's disease, is also composed of epithelial and lymphoid elements, but is a distinct clinical and pathological entity.

6 Treatment of Mikulicz's disease is surgery or radiation or a combination of both. The response to radiation is good and recurrences are few.

7 Sacrifice of the facial nerve is not justified in either Warthin's tumor or Mikulicz's disease.

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SOME OTOLARYNGOLOGICAL ASPECTS OF CEREBROVASCULAR DISEASE[*]

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Cerebrovascular diseases constitute the nation's third ranking killer. It has been estimated that as many as 1,800,000 living Americans have suffered strokes, and that deaths due to such strokes total nearly 175,000 annually. Many strokes are preceded by transient warning episodes which may first be called to the attention of otolaryngologists. In particular, symptoms suggestive of inner ear disease may be due to cerebrovascular disease. Such disturbances may remain obscure unless thought of in the light of a cerebrovascular lesion. Numerous personal experiences with vascular complications prompted this review of the subject.

The principal types of cerebrovascular disease are atherosclerotic occlusion with cerebral infarction, transient ischemia without infarction, intracranial hemorrhage, vascular malformations and developmental abnormalities, inflammatory disease of arteries, hypertensive encephalopathy and dural sinus and cerebral venous thrombosis.

The number and variety of neurologic symptoms and signs that may be encountered are almost unlimited and their recognition requires a knowledge of neurology. Recognition of impending strokes has become very important, in that medical measures such as the use of anticoagulants or surgical intervention may prevent a catastrophic outcome. These warning attacks usually last from two to ten minutes. Many attacks may occur over a period of weeks or months. The syndromes of impending stroke may manifest themselves from the territory of each of the major cerebral arteries as follows:

1. Middle cerebral artery: contralateral mono- or hemi-

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Case 3 A T, 69, male The day before admission he awoke with tinnitus on the left, occipital headache and dimness of vision in the left eye (right eye blind from trauma in childhood) Left carotid compression produced dimness of vision but no syncope Bilateral carotid arteriograms showed arteriosclerotic placques in the proximal portion of both internal carotids, the left carotid being occluded

Case 4 S B 62, female, admitted with headaches and right sided tinnitus Left carotid compression resulted in syncope Right carotid angiogram showed arteriosclerotic changes in the right internal carotid artery just distal to the bifurcation and at the syphon There was also anterior cerebral artery occlusion at its origin

Case 5 E D, 51 male, admitted with dizzy spells of eight months' duration, which were relieved by lying down and parasthesias in the right arm Bilateral compression produced dizziness Arteriograms revealed a right carotid artery occlusion

Case 6 J L 63 male Three weeks previous to admission, patient had sudden onset of dizziness with nausea and vomiting and pulsating tinnitus in the right ear The audiogram and caloric tests were normal Left carotid compression produced syncope Arteriograms revealed right carotid artery occlusion

Case 7 M.F, 80, female admitted with dizziness and bilateral tinnitus of two weeks' duration On the morning of admission she developed generalized weakness vomiting and speech disturbances Left carotid compression resulted in syncope Carotid arteriograms showed bilateral placques with occlusion of the right anterior cerebral artery

Case 8 A H, 67 male admitted with dizziness of two months duration Left carotid compression slowed the pulse to 35 Right carotid compression produced asystole Autopsy revealed vertebral artery occlusion with evidence of infarction

Case 9 A F 71, female left pounding tinnitus for two months and dizziness for a month before admission Tinnitus relieved by carotid compression The caloric test was normal The audiogram showed a moderate degree of nerve type hearing impairment bilaterally Carotid compression produced syncope Arteriograms showed almost total occlusion of the left carotid A small placque was noted on the right carotid

Case 10 J W 62 male admitted with severe vertigo and persistent left tinnitus of six months duration Audiograms show a bilateral symmetrical nerve type of hearing impairment A weak caloric response was obtained on the left Bilateral carotid compression produced syncope EEG reported as showing a bi-temporal dysrhythmia (slowing) suggesting a mid line disturbance probably vascular Right carotid and vertebral arteriograms showed a normal right carotid and a straightening and elongation of the basilar artery indicating arteriosclerosis but without obstruction The vertebral arteries were normal

The symptoms of the patients above described although in part otological are actually a result of cerebrovascular insufficiency This insufficiency is frequently due to occlusive disease of the carotid vertebral basilar system

DISCUSSION

The increased diagnostic use of carotid arteriography and routine examination of these arteries in autopsy examinations, paresis, numbness, tingling, dysphasia, homonymous hemianopia or scintillating scotomata

2 Anterior cerebral artery weakness or numbness of the upper limb, confusion, psychotic manifestations and incontinence

3 Posterior cerebral artery homonymous hemianopia, scintillating scotomata, and if there is bilateral involvement, temporary or permanent blindness

4 Internal carotid artery contralateral weakness, numbness or dysphasia, transient blindness on the side of the occluded vessel and reduced pulsation of the common or internal carotid artery in the neck or inside the pharynx

5 Vertebral-basilar arteries dizziness, monoparesis, hemi- or quadriparesis, numbness involving both sides of the body, staggering, ataxia, diplopia, dysphagia, dysarthria, tinnitus, deafness, visual disturbances, temporary confusion or loss of memory and unconsciousness Characteristically the complaints are bilateral in vertebral-basilar disease and unilateral in middle, anterior, and posterior cerebral and in internal carotid involvement

CASE HISTORIES

A brief report on a group of ten cases will serve to illustrate the symptomatology and the diagnostic procedures and findings in representative cases

Case 1 W D , 63, male, was admitted to Detroit Memorial Hospital because of hoarseness due to left vocal cord paralysis of several weeks' duration Treated for two years for hypertension Right carotid compression resulted in syncope Carotid arteriograms showed complete occlusion of the left internal carotid artery just distal to its origin Carotid artery exploration confirmed the total occlusion The artery was ligated distal to the occlusion, and a left cervical sympathectomy was done Long term anticoagulant therapy was instituted The vocal cord paralysis was probably due to a coexistant infarction of the vagus nucleus in the medulla resulting from vertebral basilar disease

Case 2 E P , 53, male, admitted with tinnitus and progressive left hearing impairment of seven years' duration Two weeks previous to admission he had a sudden onset of dizziness, throbbing headaches and difficulty in moving the right leg Right carotid artery compression resulted in blurred vision dizziness and diplopia Left carotid compression produced numbness in the right hand Left carotid arteriogram showed arteriosclerotic changes within the proximal portion of the left internal carotid artery bulb is applied carefully with the patient sitting upright An assistant notes the pulse while the carotid bulb is first gently palpated and then gradually compressed At the first sign of syncope or convulsive movements, the compression is released and the patient is put in a supine position. This test has not proved dangerous in hundreds of cases but it must be used cautiously Usually compression for 10 to 20 seconds is required before syncope occurs from the induced acute cerebral ischemia An immediate onset of syncope, which is much less common (five seconds), usually indicates a "sensitive carotid sinus

No abnormality is noted on compression or palpation of the carotid bifurcation in young healthy individuals in others one of three responses or various combinations of these may be obtained

1. There may be an irritable carotid sinus and on compression or palpation of the carotid sinus there is produced a prompt asystole followed by syncope often within five seconds Loss of consciousness is abrupt without aura There is no memory of the experience. The asystole is produced by the cardio-inhibitory vagal reflex which may be abolished with atropine

2 Another response infrequently seen is a severe drop in blood pressure as a result of a vasodepressor reflex There is question as to whether this is a carotid sinus effect or a reflex effect with vasodilation in the gastrointestinal and muscular vascular bed. Such vasodepressor effects according to Gurdjian et al [illegible] are seen in the patients undergoing venipuncture, observing blood or bleeding witnessing an operation etc. Usually the phenomenon cannot be repeated.

3 Syncope may occur without bradycardia or vasodepression This third type of reaction has been called the cerebral form of carotid sinus irritability. Gurdjian [illegible] and his co-workers have found that this reaction is due to occlusive vascular disease involving the opposite carotid the anterior cerebral or the basilar arteries They conclude that this type of syncope is due to ischemia of the brain A carotid sinus inhibitory reflex may of course be superimposed upon the

have shown that carotid artery occlusion exists much more often than was formerly believed Advanced atherosclerosis, including complete obstruction of one or both of the carotid vessels, was found in 9 5 per cent of 432 consecutive routine autopsies in which the carotid arteries were deliberately studied [2] Many recurring temporary neurologic episodes previously considered to be caused by "vasospasm" and the "little strokes" of Alvarez, are now believed to be due to carotid artery occlusion [1] The site of involvement is usually located at the bifurcation of the common carotid artery or in the proximal portion of the internal carotid artery Less commonly the common carotid is involved

Three general clinical carotid syndromes are recognized

1 The apoplectic type with a sudden onset of severe neurologic symptoms due to complete and rapid occlusion of the carotid artery The findings may be a contralateral hemiplegia, visual disturbances on the affected side, aphasia and coma It may be rapidly fatal, or the patient may survive with varying degrees of permanent neurologic sequelae This type occurs in 35 per cent of patients with carotid artery occlusion [6]

2 The episodic type, with transient recurrent episodes of fainting, dizziness, paresthesias, paresis, aphasia and visual disturbances They may recur over a period of many months and often terminate in hemiplegia This type is noted in about 40 per cent of patients

3 The progressive type, exhibiting a slowly progressive course with headache, paresthesias, paresis, irritability, memory loss, depression and mental regression This type occurs in about 25 per cent of the cases The nature of the progression often mimics a brain tumor

Once the possibility of a cerebrovascular lesion is considered, several diagnostic procedures may be carried out They are lumbar punctures, air studies, electroencephalography, carotid compression tests, ophthalmodynamometry, and angiography

The carotid sinus reflex test can be carried out at the time of the initial examination Digital compression of the carotid bulb is applied carefully with the patient sitting upright An assistant notes the pulse while the carotid bulb is first gently palpated and then gradually compressed At the first sign of syncope or convulsive movements, the compression is released, and the patient is put in a supine position This test has not proved dangerous in hundreds of cases, but it must be used cautiously Usually, compression for 10 to 20 seconds is required before syncope occurs from the induced acute cerebral ischemia An immediate onset of syncope, which is much less common (five seconds), usually indicates a "sensitive carotid sinus"

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3 Syncope may occur without bradycardia or vasodepression This third type of reaction has been called the cerebral form of carotid sinus irritability Gurdjian[3-] and his coworkers have found that this reaction is due to occlusive vascular disease involving the opposite carotid, the anterior cerebral or the basilar arteries They conclude that this type of syncope is due to ischemia of the brain A carotid sinus inhibitory reflex may, of course, be superimposed upon the ischemic response In the presence of occlusive carotid artery disease, collateral circulation may exist to a degree which precludes syncope, but dizziness, malaise, contralateral numbness or weakness may occur Contralateral convulsive movements are commonly seen, particularly in the arm Syncope usually occurs just before the onset of the convulsive movements, these movements may then increase as the patient regains consciousness Change in mental status, such as confusion, disorientation, agitation, and an appearance of fear followed by amnesia are common Usually the patients are asked to count as the compression is applied They are unable to continue with the onset of the ischemic effect, often before syncope begins

Arteriography of the carotid and the vertebral systems may then be indicated It is the most satisfactory method for diagnosing carotid artery occlusion The contrast media must be injected low in the neck to examine properly the entire carotid system Carotid angiography has occasionally been followed in the past by hemiplegia and visual disturbances, which were transient in the great majority of cases These complications are much less common now due to improved contrast media Arteriography has its limitations in that small blood vessels are not well outlined with present day techniques

TREATMENT OF CAROTID OCCLUSION

Anticoagulant drugs may have considerable value in the prevention of a thrombotic occlusion Symptoms of intermittent transient attacks of vertigo, paresthesias and paresis may precede the formation of a massive thrombosis or the extension of a thrombus The use of anti-coagulants in these cases may be of considerable temporary value The use of drugs to counteract arterial vasopasm have not produced satisfactory results [1]

Various types of surgical operations have been used They include thromboendarterectomy (intimectomy), resection and external carotid anastomosis, resection of the involved portion of the artery with replacement by an arterial homologous graft, and resection with replacement by prosthesis[4,5] A concomitant sympathectomy may be done to increase the vascular supply to the head

CONCLUSIONS

1 A diagnosis of "stroke," "cerebral thrombosis," "cerebrovascular disease" and "embolism" may be related to ischemia of the brain, due to occlusive disease of the carotid-vertebral artery system

2 Carotid-vertebral arterial occlusive disease may become manifest by the appearance of transient warning signs and symptoms, some of which are first called to the attention of otolaryngologists

3 Recognition of these "warnings" are important, in that appropriate steps may be taken to prevent a catastrophic "stroke"

4 The carotid compression tests can be done at the initial examination to determine the adequacy of the carotid circulation

5 This test should become a common diagnostic procedure, especially for differentiating obscure otological conditions

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THE FIRST ONE HUNDRED CASES OF HEARING IMPROVEMENT IN STAPES MOBILIZATION—A LONG TERM REPORT *†

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The first case of hearing improvement following mobilization of the fixed stapedial footplate by Rosen[1] occurred in April, 1952. Since then many patients with otosclerotic deafness have been operated upon by the indirect method of stapes mobilization, which consists of exerting pressure in a posterior direction on the neck of the stapes. The direct method of mobilization at the footplate itself and the technique of fenestration of the oval window were subsequently developed and reported by the same author.[2,3]

In our first statistical report of the results achieved by the indirect method of stapes mobilization,[4] read at the Fifty-Ninth Annual Meeting of the American Laryngological, Rhinological and Otological Society in March, 1955, one of the questions we asked was "Will the hearing restored by this technique last?" Of 61 improved cases included in that report, eleven were then more than one year after mobilization, while two were over two years.

It seems appropriate at this time, almost seven years after the first mobilization, to examine the postoperative hearing data of the earliest 100 successful cases to determine:

1. How many of these patients have retained their maximum postoperative hearing improvement.

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†Data for the report of results assembled by John Guerriero, A.B., Staff Audiologist.

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2 How many showed partial regression in hearing from the best levels recorded postoperatively, but who still have significantly better hearing than they did preoperatively

3 How many suffered complete regression of hearing to their preoperative thresholds, and when such regression occurred

4 How many of the regressed cases were revised and with what results

5 How many were revised in an effort to obtain still more improvement and with what results

SELECTION OF CASES

The 100 cases included in this follow-up had all been operated upon by the indirect method of mobilization of the fixed stapedial footplate by exerting pressure on the neck of the stapes, as reported by Rosen in 1953[5] They are the earliest chronologically consecutive cases with adequate test data in which recent follow-up tests were available or could be obtained Any early case where follow-up data was unobtainable was excluded from this study Twenty-four cases among the early chronologically consecutive cases had to be excluded because recent follow-up data were unavailable for the following reasons two patients deceased, 18 patients, present address unknown, four patients did not return for follow-up tests despite requests to do so

The criterion for significant improvement was a gain in hearing, as noted by the speech reception threshold (SRT) of 15 db or better Conversely, hearing was recorded as having regressed if the most recent test data showed the SRT to be worse by 15 or more db than the best SRT recorded postoperatively Among the latter group, a case was considered to have regressed completely if the SRT was less than 15 db above the preoperative level, and partially regressed if the patient still had an SRT better by 15 db or more than the preoperative level The mean error between SRT's and pure tone threshold averages at 500, 1 000 and 2,000 cps on the equipment used in the follow-up testing of all patients in this series was 0.57 db, with a standard deviation of 4.94.

FINDINGS

Of the 100 cases included in this study, 80 were found to have maintained their maximum improvement levels without regression or without further surgery. Ten of these submitted to further stapes surgery in the previously operated ear for the purpose of improving their hearing beyond the levels obtained on the first operation. At the time of the revisions, none of these cases had shown any regression. The remaining 20 patients showed regression in hearing, 16 completely and four, partially. These data are summarized in Table I, which also shows the length of time from the date of surgery to the most recent hearing test.

TABLE I

Duration of Best Postoperative Thresholds in Non regressed Cases

Duration	No of Cases	
1 to 6 months	0	
7 to 12 months	6	*
13 to 18 months	2	
19 to 23 months	0	
2 to 3 years	2	
3 to 4 years	29	
4 to 5 years	35	
5 to 6 years	5	
Over 6 years	1	
Total	80	

*These ten cases were revised to increase their hearing still further as just stated.

From Table II we see that two of the improved cases regressed completely within the first six months after operation, two cases regressed within seven to 12 months postoperatively, three cases between 13 and 18 months, two cases between 19 and 23 months, four cases between two and three years and three cases between three and four years postoperatively.

Of the 16 cases of complete regression, nine were revised, with seven once again enjoying and maintaining significantly improved hearing

Of the four cases which showed partial regressions from the best levels reached postoperatively, one had maintained the maximum improvement for almost four-and-a-half years, another for almost four years, a third for almost three-and-a-half years, and the fourth for about two years In the Table which follows, note that Cases Nos 1 and 3 still hear at a threshold level of 30 db, while No 4's threshold of 40 db is still 20 db better than before the surgery four years and eight months previous to his most recent test

TABLE II

REGRESSED CASES

Duration of Best Postoperative Thresholds Before Regressions Occurred

Duration	No of Cases Completely Regressed	No of Cases Partially Regressed
1 to 6 months	2	
7 to 12 months	2	
13 to 18 months	3	
19 to 23 months	2	1
2 to 3 years	4	
3 to 4 years	3	2
4 to 5 years	0	1
Total	16*	4

*Six of the 16 had originally achieved only a 15 db improvement in hearing sufficient gain though small to be included in the improved cases If however they were found to have even 5 db less hearing on subsequent tests they were considered to have regressed completely Of all the regressed cases none showed hearing which was worse than their preoperative hearing

TABLE III

PARTIAL REGRESSIONS

Case No	Preop Threshold	Best P O Threshold	Duration of Best P O Threshold	Present Threshold	Total P O Period
1	50 db	15 db	53 months	30 db	58 months
2	55 db	25 db	47 months	40 db	52 months
3	50 db	15 db	41 months	30 db	50 months
4	60 db	25 db	23 months	40 db	56 months

Ten of the patients who were considered to have had significant improvement in hearing following the first stapes mobilization were dissatisfied with their postoperative hear-patients in this series was 0.57 db, with a standard deviation of 4.94.

FINDINGS

Of the 100 cases included in this study, 80 were found to have maintained their maximum improvement levels without regression or without further surgery. Ten of these submitted to further stapes surgery in the previously operated ear for the purpose of improving their hearing beyond the levels obtained on the first operation. At the time of the revisions, none of these cases had shown any regression. The remaining 20 patients showed regression in hearing, 16 completely and four, partially. These data are summarized in Table I, which also shows the length of time from the date of surgery to the most recent hearing test.

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Of the 16 cases of complete regression, nine were revised, improvement did not gain more hearing, but remained at the postoperative threshold achieved at the first operation They are, therefore, included among the cases which maintained full improvement by stapes mobilization at the neck

Table IV summarizes the present status of the first 100 cases included in this report

SUMMARY

This report contains a follow-up study of the present hearing of the first 100 successful cases of stapes mobilization Eighty-three of these patients have maintained significantly improved hearing for from three to seven years Following successful revision of seven of the regressed cases, 90 of the original 100 successful cases today enjoy significantly improved hearing

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ing levels and were reoperated in an attempt to improve their hearing further. Following the first operation, the threshold of one of these patients had been improved from 55 db to 40 db. Twelve months later she was reoperated by the direct method of footplate mobilization. (The crura were found to have been fractured at the initial operation.) The hearing improved after the second operation to the 15 db level by speech reception threshold, which has been maintained for over three-and-a-half years.

TABLE IV

Summary of the Present Status of the First 100 Cases Improved by Stapes Mobilization (Rosen)

	No. of Cases
1. Maintained Full Improvement	79
2. Successfully Revised Following Complete Regression to Preoperative Thresholds	7
3. Partially Regressed but Still Significantly Improved Over Their Preoperative Levels	4
Total with Significantly Improved Hearing at Most Recent Hearing Test	90
4. Completely Regressed to Preoperative Threshold and Unimproved by Attempted Revision	2
5. Completely Regressed, No Attempts at Revision	7
6. Dropped to Original Preoperative Level by Attempted Revision to Improve Hearing Further	1
	10
Total Cases	100

Another of these patients who had also improved only from a preoperative threshold of 55 db to a postoperative 40 db, was revised 12 months after the first operation. A fenestration of the oval window was performed, and the patient now has a remarkable improvement to her present threshold of 10 db, three-and-a-half years following footplate fenestration.

A third case revised in an attempt to increase the gain in hearing 13 months after the original operation had brought the hearing from a preoperative threshold of 60 db to 45 db, returned to the 60 db level following the revision attempt.

The remaining seven cases of the ten revised for further to five years ago developed out of 206 attempts to mobilize the stapes in patients whose hearing loss occurred from stapediovestibular otosclerosis This represents a temporary success rate of 49 per cent, and all but four of these were mobilized by engaging a pick in the head of the stapes, as previously described in 1955[1] The four exceptions were mobilized by the pulsating technique applied to the head and neck of the stapes, reported by Rosen[2] All but 17 patients have had audiograms during the past six months The rest have had audiograms during the past year

SUCCESSES

Among the first 100 successes, 54 have maintained their gain of 15 db or more in the speech frequencies of 500, 1,000 and 2,000 cycles per second Thirty-four of these have hearing of better than average 30 db including 16 which have closure of the air-bone gap Only two of the remaining 20 also have closure of the air-bone gap Closure of the air-bone gap is defined as a difference of ten db or less between the preoperative bone conduction threshold and the postoperative air conduction threshold (see Table I)

TABLE I

At least 15 db improvement	54	
Hearing better than 30 db		34 (16)*
Not better than 30 db		20 (2)*

*(16 and 2)—Closure of the air-bone gap

REGRESSIONS

Regression is defined as a decrease of hearing to any threshold below all of the categories of success In other words, when an initial success subsequently drops to any level below the "15 db gain," "better than 30 db," and/or "air-bone gap closure" category, it is considered a regression Among the first 100 successful ears, 46 regressions subsequently occurred as follows (see Table II)

Nineteen of these 46 regressions have been reoperated and

LATE HEARING RESULTS IN MOBILIZATION SURGERY*†

C M Kos, M D ,

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The destiny of the various techniques for securing stapes mobility may not be clearly projected, but time is beginning to furnish some clues concerning the practicability of continuing to attack the stapediovestibular junction as the logical approach to solving the problem of otosclerotic ankylosis Currently enthusiasm seems to prevail for the improvement in results achieved over the past five years, and for the promise of new developments in surgical technology that are continuing to evolve from experimentation

At the outset it was generally conceded that the obstacles to obtaining stapes mobilization would not be too difficult to overcome Subsequent events seem to have confirmed this prediction It is probably conservative to estimate that 80 to 90 per cent of otosclerotically fixed stapes may be at least partially mobilized by the present methods of approaching the footplate directly, however, regressions continue to occur in proportionately increasing numbers to detract from the gains made in the rate of mobilization

According to gross and microscopic observation, it is apparent that the disposition and the extent of the otosclerotic process in the stapediovestibular joint is distributed in such peculiar patterns in the population so as not only to defeat efforts to mobilize some, but also to limit the numbers of long term results A study of early experiences reveals some interesting facts

The first 100 immediately successful results obtained three

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*Read at the Sixty-Second Annual Meeting of the American Laryngological Rhinological and Otological Society Inc , Hot Springs Va March 12 1959

†From the Department of Otolaryngology and Maxillofacial Surgery University Hospitals Iowa City, Ia

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four of these operations was the engagement of the pick on the capitulum of the stapes With experience the results have improved A total of 707 operations were performed by this technique during the period 1954 through 1957 Sixty-five per cent of these were initially successful As of Dec 31, 1958, 58 per cent, or a little over one-half of the initially successful gains have been maintained The regression rate is 42 per cent

Comparing these results with 179 operations performed during the past two years with chisels applied directly to the periphery of the footplate, 83 per cent were initially successful As of Dec 31, 1958, 62 per cent of the initially successful gains have been maintained The regression rate is 38 per cent

TABLE III

Summary of Results

	6 Weeks	3-5 Yrs	Regressions
At least 15 db improvement .	100	54	46
Hearing better than 30 db	63 (23)*	34 (16)*	29 (7)
Hearing not better than 30 db	37 (2)*	20 (2)*	17 (0)

( )*—Closure of air-bone gap

Despite the initial superiority of the chisel-footplate technique over the pick-capitular technique regressions continue to undermine the sustained results As such evidence arises, gradual shifts to variations and modifications of the operation are made The current trend is toward artificial struts[3] and footplate substitution techniques,[4] which may reduce the incidence of regressions and, therefore, assure a larger number of sustained improvements

SUMMARY

Three to five years after stapes mobilization by the pick-capitulum technique, 54 of 100 initially successful operations are still successful according to the criteria set forth above Forty-six have regressed, 28 of these before one year postoperatively six have subsequently regressed again At least two of the regressions occurred because of ischemic necrosis of the lenticular process which developed from circulatory trauma of the pick on the capitulum It is believed that most of the other regressions occurred as the result of reankyloses due to otosclerosis or fibrosis of the footplate Two patients have since had successful fenestration operations—one after the initial attempt to mobilize the stapes and one after two attempts to secure mobilization The low incidence of fenestrations is due to the fact that in the early stages of mobilization surgery most of the patients selected were not suitable for fenestration surgery The others have not been reoperated for various reasons classified under the notation "inadvisable to operate again"—usually complete displacement by otosclerosis

TABLE II

a 28 regressed before one year after surgery—most of them within three months
b 5 regressed between one and two years after surgery
c 11 regressed between two and three years after surgery
d 2 regressed between three and four years after surgery

COMPLICATIONS

Some complications occurred among the maintained successes as well as among the regressions There were two instances of purulent otitis media, one which responded promptly to treatment with recovery of the hearing gain, and one which eventually resolved without hearing improvement Another patient developed serous labyrinthitis—unusual because a severe hearing loss ensued which after intense therapy regained the initial improvement The details have been published elsewhere[1] Two patients whose hearing improvement subsequently regressed continued to complain of chorda tympani injury

COMMENT

It should be emphasized that the technique used in all but four of these operations was the engagement of the pick on the capitulum of the stapes With experience the results have improved A total of 707 operations were performed by this technique during the period 1954 through 1957 Sixty-five per cent of these were initially successful As of Dec 31, 1958, 58 per cent, or a little over one-half of the initially successful gains have been maintained The regression rate is 42 per cent

Comparing these results with 179 operations performed during the past two years with chisels applied directly to the periphery of the footplate, 83 per cent were initially successful As of Dec 31, 1958, 62 per cent of the initially successful gains have been maintained The regression rate is 38 per cent

TABLE III

Summary of Results

	6 Weeks	3-5 Yrs	Regressions
At least 15 db improvement –	100	54	46
Hearing better than 30 db	63 (23)*	34 (16)*	29 (7)
Hearing not better than 30 db	37 (2)*	20 (2)*	17 (0)

( )*—Closure of air-bone gap

Despite the initial superiority of the chisel-footplate technique over the pick-capitular technique regressions continue to undermine the sustained results As such evidence arises, gradual shifts to variations and modifications of the operation are made The current trend is toward artificial struts[3] and footplate substitution techniques,[4] which may reduce the incidence of regressions and, therefore, assure a larger number of sustained improvements

SUMMARY

Three to five years after stapes mobilization by the pick-capitulum technique, 54 of 100 initially successful operations are still successful according to the criteria set forth above Forty-six have regressed, 28 of these before one year postoperatively

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TRANSTYMPANIC VESTIBULOTOMY FOR MENIERE'S DISEASE*†

B W ARMSTRONG, M D ,
Charlotte, N C

Transtympanic labyrinthotomy is the simplest of the surgical procedures for Meniere's disease available today[1,2] The results reported have been good, although some patients have had recurrence of vertigo[2] A new technique is presented that should produce uniformly good results without recurrences

Surgical treatment of Meniere's disease is indicated when medical management fails to control the attacks Surgery is also indicated in certain patients whose anxiety over the possibility of another attack renders them psychologically incapacitated It is to be sure that patients deserve a careful history and examination, as well as a trial on an appropriate medical regimen before subjecting them to labyrinthotomy

TECHNIQUE

The operation presented represents an attempt to avoid the failures occasionally experienced with earlier methods[2,3,4,5] The objective is destruction of the entire statico-dynamic function of the labyrinth The position of the macula utriculi and the macula sacculi in relationship to the round window and the stapes is clearly seen in Fig 1 By removing the stapes *and* the promontory between the round and oval windows one can obtain direct access to the saccule, utricle, common crus, non-ampullated end of the horizontal semicircular canal, and the ampullated end of the posterior semicircular canal In this way the ultimate loss of all vestibular function can be assured

General anesthesia is employed to avoid vertigo, nausea,

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†From the Charlotte Eye Ear and Throat Hospital

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Thirty-four of the 54 sustained improvements have a hearing threshold of better than 30 db, and 18 of the 54 resulted in a closure of the air-bone gap (see Table III)

The chisel-footplate technique is superior to the pick-capitulum method, but regressions continue to take a proportionate toll of sustained results The technically more difficult uses of artificial struts and footplate substitutes which are being phased in with our past experiences may offer better prospects of permanency

ACKNOWLEDGMENT

The indispensable statistical evaluation provided by Dr James L Shapley, Ph D, and Patricia Iles, B A, is gratefully acknowledged

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tective scar The drum and flap are replaced An antibiotic is administered for the first five days after operation

RESULTS

This is a new, but clinically promising technique Only three patients have been operated upon in the manner described All had a long history of recurrent attacks of vertigo with nausea and vomiting, plus the usual tinnitus and progressive unilateral loss of hearing All had an ample trial on medical treatment, and all failed to respond In each instance there has been relief of vertigo and loss of caloric response as well as total loss of hearing in the ear subjected to surgery Two patients were relieved of their tinnitus, but the other patient still complains of roaring in her ear Convalescence has not been materially different from other types of labyrinthotomy

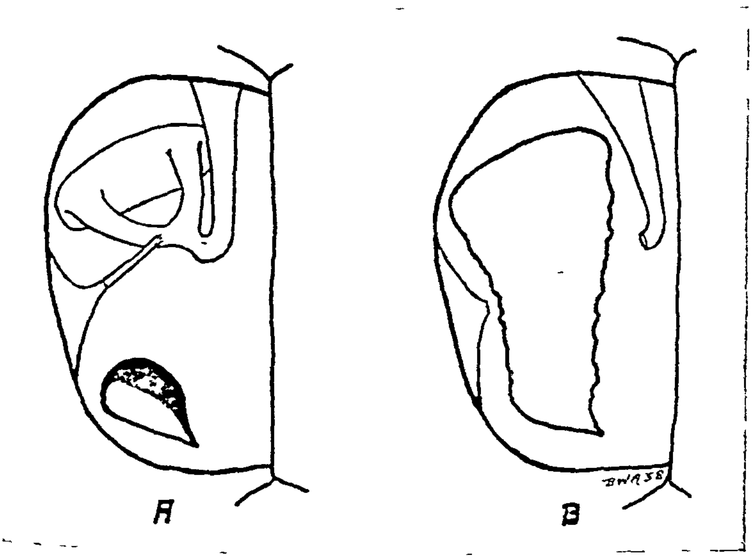

Fig 2 A Diagrammatic representation of the operative field B Stapes has been removed and the round window connected with the oval window by removing the intervening bone

and vomiting during the operation Hemostasis and supplementary anesthesia are obtained by infiltrating approximately 1 cc of a mixture composed of equal parts of procaine 1 per cent and epinephrine 1 1000 The incision is made and the skin flap elevated in the usual manner for transtympanic surgery

The incudostapedial joint is disarticulated and the stapedius tendon divided The stapes is gently rocked with a rotary motion to loosen it, so that it can be removed intact by grasping the capitulum with middle ear forceps A small curette is then introduced into the round window, and the bone between the two windows is carefully removed (see Fig 2) The contents of the vestibule are removed by *gently* curetting the medial wall and scrubbing it with a cotton-tipped applicator Vigorous curettage could result in a cerebrospinal fluid leak through the cribriform area leading to the internal auditory meatus and should be avoided The vestibule is lightly packed with gelfoam to promote organization of a firm pro-

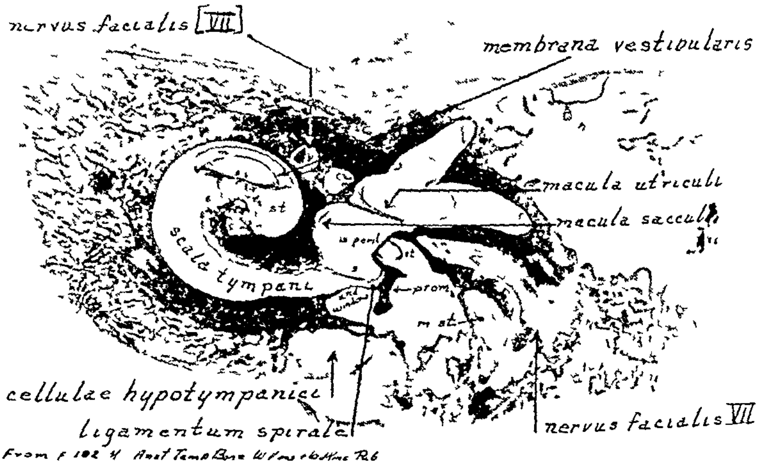

Fig 1 Photomicrograph of a vertical section cut in the plane of the long axis of the petrosa St—stapes Modified by D Wolff and reproduced with permission from Microscopic Anatomy of the Temporal Bone' Wolff, Bellucci and Eggston The Williams & Wilkins Company Baltimore Md

tective scar The drum and flap are replaced An antibiotic is administered for the first five days after operation

RESULTS

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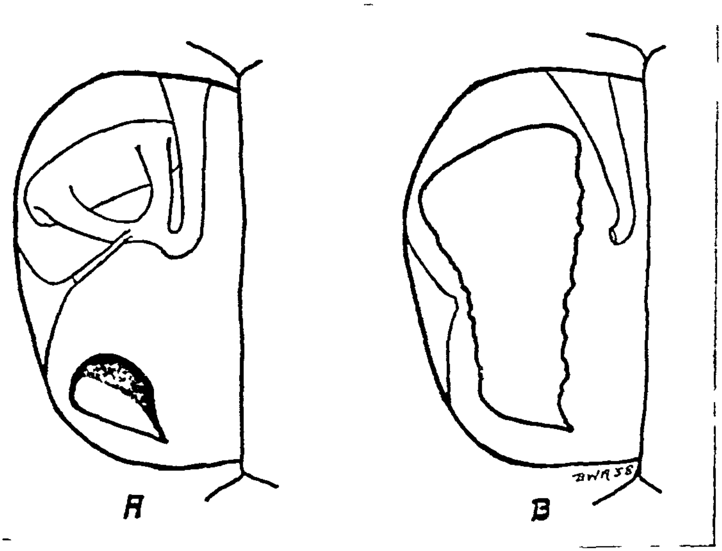

Fig 2 A. Diagrammatic representation of the operative field B Stapes has been removed and the round window connected with the oval window by removing the intervening bone

SUMMARY

A transtympanic technique that insures the destruction of the vestibular end-organs has been presented. One need not fear the unfortunate complication of facial paralaysis that has occasionally followed attempts to destroy labyrinthine function by injection of alcohol or electrocoagulation[3] The operation described should eliminate the failures occasionally encountered with previously described operations Experience with more cases will be necessary before final appraisal of this procedure is possible

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NEURILEMMOMA OF THE FACIAL NERVE*

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and
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Neurilemmoma of the facial nerve is not a common condition. In a recent article in which he reported a case, Sarkar[1] stated that he had found 32 cases in the literature and documented them; his case made a total of 33. In most of the cases the primary symptom was a facial paralysis and the presenting sign a mass in the external auditory canal often diagnosed as a polyp. In many cases the erroneous diagnosis of Bell's palsy had been made and Kettel[2] reports such a case.

It is our purpose here to report four additional cases of neurilemmoma of the facial nerve. The first is not extraordinary, in that the presenting signs were a mass in the external auditory canal and a complete facial paralysis that had been present for some years. No definite diagnosis was made before operation.

The second case had been diagnosed as Bell's palsy by a neurologist, and the patient was referred to one of us (T.E.W.) for decompression of the nerve. Examination of the ear revealed an intact drum with a tumor mass occupying the posterior part of the middle ear. X-rays were not revealing, and the diagnosis of neurinoma of the facial nerve was made and confirmed at operation.

The third and fourth cases are of special interest, in that they both had intracranial extension of the neurilemmoma which arose in the horizontal portion of the nerve. They both were seen by one of us (L.T.F.) because of the signs of intracranial pathology. In one the tumor could be seen in

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the middle ear behind an intact drum In the other there was no evidence of intratympanic pathology

Case 1 M D, female, age 35, was first seen in April, 1948, complaining of "trouble with the left ear and paralysis of the left side of the face" The trouble had started with tinnitus in the left ear in March, 1938 Eustachian tube inflations and tonsillectomy were performed with no effect on the tinnitus In the Spring of 1939, some loss of facial movement was first noticed, and paralysis gradually became complete The patient was seen at the Mayo Clinic in 1940 and an exploratory operation on the left ear was suggested but was not performed In November, 1947, she experienced dizzy spells which were accompanied by nausea and vomiting These spells had continued There was no hearing in the left ear, and she had had no pain, headache nor change in taste

Examination in April, 1948, revealed a complete left facial paralysis In the left external auditory canal was a large red mass which was covered with skin and appeared attached both to the floor and to the roof of the canal It was not possible to see past the mass, nor to examine the drum A biopsy of this mass was not done, but it was felt that it must be removed by surgery There was no hearing in the left ear

At operation, a tumor mass was found eroding the posterior bony canal wall and filling the mastoid cavity This was of a soft consistency, yellowish in color and bled fairly easily The posterior fossa dura was exposed by the tumor which also filled the middle ear The horizontal canal was eroded The mass seemed to arise from the facial nerve both ends of which, superiorly close to the geniculate ganglion and inferiorly at the stylomastoid foramen, could be identified The tumor was removed, and a graft, taken from the auriculotemporal nerve, was used The patient did well postoperatively, except that there was no return of facial function

She returned in March, 1949, complaining of continuing dizzy spells which were disabling and at that time was re admitted and electrocoagulation of the left labyrinth was performed Since then she has had no further trouble except for a minimal discharge from the cavity

Case 2 B R, female, 16, was first seen in September, 1950 This patient had been seen by a neurologist some seven or eight years previously complaining of a complete facial paralysis This had been diagnosed as Bell's palsy, and she was told that nothing could be done about it There was no recovery of function, and there was complete atrophy of the muscles on the right side of her face She had had no pain and no difficulty with eating during this period, and the only real difficulty was epiphora of the right eye

Examination of the right ear revealed a smooth swelling of the posterior half of the drum The pars tensa moved freely over a mass in the middle ear This mass when palpated with a cotton tipped applicator had the consistency of rubber Testing for taste revealed a definite hypoactivity on the right side of the tongue The hearing was not impaired The diagnosis of neurofibroma of the facial nerve was made

In April, 1951, an operation was performed to remove the neurilemmoma A tumor was seen arising from the facial nerve and protruding into the antrum It extended from 2 or 3 mm above the stylomastoid foramen to just below the geniculate ganglion There was no erosion of the bony labyrinth nor of the ossicles Both ends of the nerve were found somewhat edematous and frayed, were freshened and a graft taken from the auricular nerve approximately 20 to 25 mm in length was inserted between the two ends Healing was uneventful and the patient made a good recovery There has been no improvement of the facial paralysis, and at a later date a fascial sling was done to improve the resting appearance of the face The postoperative hearing shows a high tone loss above 2000 cycles

Case 3 P R , a white male, age 48, resident of Indiana, was seen on April 18, 1953 In 1940 he began to develop a peripheral facial paralysis which came on gradually and first involved the superior portion of the face There was inability to blink and a smoothing out of the forehead Eventually the paralysis became complete In 1942 he was seen at the Mayo Clinic, but nothing of significance was found except for the right VIIth nerve palsy The Department of Otolaryngology reported "negative" studies and there was no Vth nerve involvement The presumptive etiology was pressure neuritis due to the patient's long established habit of sleeping with the right shoulder wedged into the right side of his face A change of sleeping posture was recommended He carried on his work as an automobile salesman and taxi driver without difficulty except for gradual loss of hearing in the right ear, which began in 1950 and was complete by 1952

In December, 1952, while applying warm compresses to the exposed right eye he was conscious of "whirling spots of bright colors" and that night during sleep he had a generalized convulsion When he regained consciousness he was in an oxygen tent in a local hospital Since that time in spite of anticonvulsive medication, he had had five other convulsions and during the last attack his left shoulder was dislocated In January, 1953 while talking to a client he suddenly got up without any reason and left the client The next thing he remembered was being in his car driving home He had an uncontrollable desire to void, was incontinent of urine, and arrived home with wet clothes but no other reasonable excuse for being there His wife volunteered that for several months he had been moody, irritable, careless in business and in dress and uninterested in his home

On examination he had no pressure signs and no Vth nerve involvement There was an obviously long standing VIIth nerve paralysis on the right with eversion of the lower lid and pronounced sagging of the right face There were no significant motor, sensory, or reflex changes and no evidences of cerebellar dysfunction He had several small cafe-au lait spots on his back but no palpable neuromata Audiometer test showed 'slight remnants" of hearing in the right ear with normal hearing on the left There was no reaction to caloric stimulation on the right except slight vertigo after four minutes of 68° water Visual fields were normal The EEG was interpreted as mixed fast and slow dysrhythmia nonfocal, consistent with convulsive disorder Radioactive isotope localization was said to indicate a right cerebello pontine angle tumor however, X-rays of the skull showed a slight displacement of the pineal to the left and a thin curvilinear calcification extending up into the middle fossa suggesting a large globular mass in this area Until the X rays were seen, in spite of the absence of Vth nerve involvement an angle tumor was suspected The films however, raised the possibility of two lesions, so angiography was done The right middle cerebral artery was displaced anteriorly superiorly and medially, so the middle fossa was explored on April 23, 1953

The temporal bone was so thin that it was fractured with a periosteal elevator A low flap was reflected The very tight dura was controlled by ventricle puncture and release of spinal fluid The sylvian fissure was found pushed upward at least three to four cms A very thin layer of temporal cortex covered a tennis ball size tumor of firm rubbery consistency The interior of the tumor was yellowish in color with an occasional small cyst Around the periphery of the tumor were several patient was discharged from the hospital and was seen in the office recently. He had resumed his former activities, and he was feeling quite well. He is still taking anticonvulsant medication.

The first case of the neurinoma of the facial nerve was reported by Schmid[3] in 1930. This was a 16-year-old girl who had a long standing facial paralysis, and a tumor mass on the posterior wall of the external auditory canal. Mastoid exploration revealed a cavity the size of a bean which was filled with granulation like tumor masses. The facial nerve was exposed in the descending portion at the bottom of the cavity and the pathological diagnosis was neurinoma arising from the sheath of the facial nerve. In 1931 Schroder[4] reported the case of a 25-year-old male who had had a facial paralysis for eight years with chronic purulent otitis media for four years. He had had two mastoid operations, and at the second operation the tissue removed was found to be neurinoma. At the third operation, a large tumor mass filling the middle ear and mastoid cavity was found and removed. An extension of the tumor into the middle fossa was not removed, but the patient was given X-ray treatment. One year later a small fistulous opening was injected with lipiodol, and the fistula was found to extend into the frontal lobe of the brain. The deafness and facial paralysis persisted.

Grossman and Leidler in 1932[5] reported a case which was later reported in detail by Altmann[6] with three other cases from the University Clinic in Vienna. This patient had had facial paralysis for 18 months, the external auditory canal was filled with polyps, there was conductive deafness with normal caloric reaction. Biopsy was reported as leiomyoma, and the patient was treated with radium. Six years later, the face was paralyzed and the patient was totally deaf. Operation disclosed a solid tumor filling the middle ear and the mastoid antrum. This tumor was removed and the sections were diagnosed as neurinoma. The patient recovered except for persistent facial.

In 1935, Altmann gave the first comprehensive report dealing with these tumors, and said that while such cases were rare the symptomatology was so clear cut that they could and should be diagnosed clinically. He reviewed the cases previously reported and gave detailed records of four additional cases, one being the patient previously reported by Grossman and Liedler From these cases he formulated the following symptom-complex The first symptom is always facial paralysis It may come on suddenly, but usually is gradual in its development and may progress in a step-like fashion Associated with the paralysis there is usually disturbance in taste, but if the tumor originates at a point distal to the chorda tympani taste may be intact When the ear is examined a "polypous tumor" is usually found which obstructs either partially or completely the auditory canal, and it seems to have arisen from the posterior wall of the canal Hearing is usually normal in the early stages, but later becomes impaired, either from external canal obstruction or by extension of the tumor into the middle ear If the tumor in the middle ear erodes through the drum, infection develops, and this long standing drainage may complicate the symptomatology He felt that irradiation of these tumors was useless, and advocated surgery as the only method of treatment, however, he felt that surgery was dangerous and to be undertaken only in the face of progression of symptoms He stressed the fact that tumor removal did not alter the facial paralysis

In a second paper in 1937, he reported an additional case and again reviewed the clinical syndrome Altmann[7] advocated preliminary biopsy in all cases, and pointed out that the tumors were of slow growth, but could by expansion and erosion, give rise to middle ear or intracranial complications

In 1936, Griefenstein[8] reported an asymtomatic VIIth nerve neuroma discovered at autopsy on a patient who had died following operation for pituitary tumor There was no preceding history of facial paralysis or deafness

In 1939 the first case in American literature was reported by Williams and Pastore[9] This was a 59-year-old man with a left facial which developed over a period of one month four years previously Five months before he appeared at the Mayo Clinic, he developed pre-auricular and mastoid pain with increasing deafness His local otologist removed a "polyp" from the external auditory canal, but the symptoms were not relieved, and the polyp recurred On examination he was found to have a complete left facial paralysis with atrophy of the facial muscles. The left ear was deaf, and a polypoid mass filled the external auditory canal. There were no other abnormal findings. X-rays were reported as showing an area of irregular destruction in the bone in the left mastoid in an area overlying the lateral sinus. The polypoid mass in the external canal was biopsied and reported as "inflammatory ulcer and granulation tissue." ✓

A radical mastoidectomy was done and a yellowish tumor mass extending into the facial canal was found and removed. The patient was given 12,000 mg. hours of radium. The facial paralysis persisted.

An additional case has been reported by Rejto,[10] but it is not available. In 1943, the literature was reviewed and an additional case reported by Roberts.[11] His was unusual in that the facial paralysis had been present for 30 years, deafness for 20, and purulent drainage for 15. He was operated upon for chronic mastoiditis, but a neurinomatous tumor which had eroded bone to become attached to the dura was found and removed. Recovery was good except for the persistent facial paralysis and deafness.

In 1944, Bogdasarian[12] reported a case in which facial paralysis had been present for five months, and vestibular function was normal. Hearing was reduced by air conduction but normal by bone conduction. A tumor mass bulging against the drum was biopsied and reported as neurinoma, so using a post-auricular approach the tumor was removed from the middle ear. The bone had been eroded by the tumor so that the dura was exposed but not invaded. Except for the persistent facial paralysis, the patient made a good recovery.

In 1946, Kettel[2] reported a VIIth nerve tumor discovered accidentally when the facial nerve was decompressed for "recurring Bell's palsy." He felt that certain aspects of the symptomatology in his case were different, *i.e.*, the paralysis improved and then recurred, no tumor could be seen in the ear, although paralysis had been present for years, and pain was a prominent symptom. In an interesting footnote, he states that the patient reported by Schroder[1] in 1931 was still alive but unable to work because of "fits of fainting and fury" On four occasions he had been in mental hospitals, the fistula was closed, and the facial paralysis was still complete

In 1953, Collins and Thomson[13] reported a case in which a tumor was excised which extended from 4 mms proximal to the bifurcation of the nerve in the parotid to within 3 mms of the genu The bony roof of the canal was opened, the tumor removed, and a graft sutured to the divided ends of the nerve The graft was successful, facial function reappearing in eight months, and the ultimate result was excellent as shown by photographs

CONCLUSION

The symptom-complex by which these tumors may be suspected while still confined to the middle ear of the mastoid has been described by Altmann Obviously it is to be hoped that all cases will be diagnosed and the tumor removed while the lesion is still so confined, for in the stage prior to complete atrophy of the facial muscles, not only may the benign tumor be removed, but it is probable that the facial paralysis will be corrected by nerve graft If, however, as in the two cases here reported, such a diagnosis is *not* made, one should be suspicious when the patient with a long standing facial paralysis begins to have either convulsive seizures or personality change Since the lesion is very slow growing and because there is considerable available space in the middle fossa, pressure signs will occur late in the course of the disease If such a lesion be suspected, the diagnosis may be confirmed by either angiography or ventriculography, but if the latter procedure is used, films to outline the temporal horns may be very valuable

When the diagnosis of Bell's palsy is made it would be advisable for the patient to be seen by a competent otologist Although neurilemmoma of the facial nerve in the middle ear is a rarity, its early diagnosis will save a complete facial paralysis and disfigurement It seems feasible to remove the tumor and graft the nerve, if this is done before atrophy of the muscles is allowed to take place

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TRENDS IN MOBILIZATION SURGERY[*][†][‡]

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Trends in stapes mobilization surgery can be established only through the medium of a thorough statistical analysis of a large series of operated cases I have little faith in statistics other than that they do establish a trend and, therefore, the title of this paper

All of my stapes mobilization cases have been processed through the medium of I B M equipment Each 50 cases has been analyzed and charted on a graph This graph allows us to visualize our results from month to month as we use various surgical techniques

PROGRESS GRAPH

The above graph depicts the percentage of stapes mobilization cases that have achieved a significant gain of 11 db or more in the three speech frequencies at the time of their three weeks' postoperative hearing test (see Fig 1) Forty per cent of my first 50 cases achieved a significant gain at three weeks At this time, the technique was predominately transcrural, using a mobilizing needle and a pneumatic hammer and working through the otoscope For the first 300 cases, my results gradually improved until 60 per cent of the cases were achieving a significant gain at the time of their three weeks' postoperative test At this point, I attempted to do the anterior crurotomy, as suggested by Fowler,[1] on 15 consecutive cases Unfortunately, fractures of both the anterior and posterior crura resulted, thus accounting for the severe drop in our immediate results The anterior crurotomy

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From the 1,800 to 2,000 case level and beyond, we have been using the polyethylene strut placed directly on the shattered bluish footplate In selected cases of solid footplate fixation, we have been using the drill and the vein graft technique, after the method of Shea[2] (Vein graft series not sufficient to be statistically valid at this writing)

It would seem from the graph that successful three weeks' results in stapes mobilization surgery does not depend upon the instrumentarium used, or where or how the manipulating pressures are applied, as long as adequate mobilization of the footplate is achieved with an intact ossicular chain or adequate substitution of this ossicular chain In this series the substitution used was the polyethylene strut with or without a vein graft Other substitution techniques include the tantalum or steel wire (Schuknecht[3]) and the posterior crus repositioning (Juers[4])

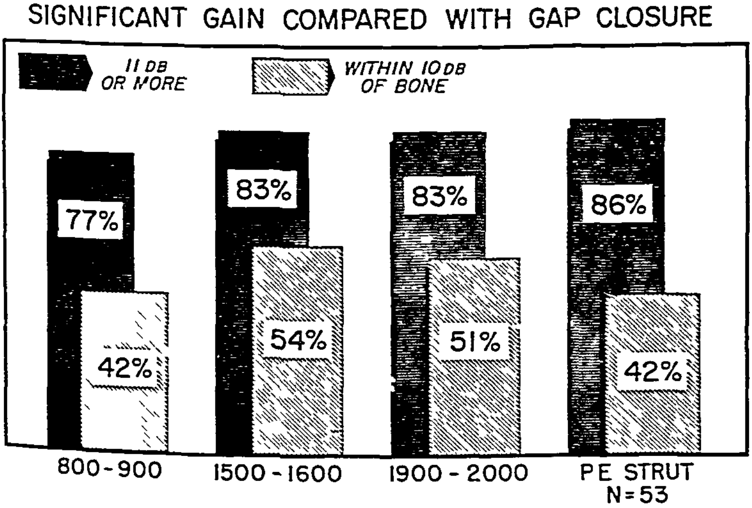

Fig 2

SIGNIFICANT GAIN COMPARED WITH TOTAL GAP CLOSURE

A random spot study in groups of 100 cases of significant gain compared with total closure of the bone-air gap failed approach was discarded, and gradually our results again improved At the 750 case level, a solid otosclerotic footplate was shattered with the pneumatic hammer applied directly in the center of the footplate The patient became very vertiginous and two days later I realized that the patient had suffered an inner ear traumatic injury At this point, the pneumatic hammer was discarded, and only the needle was used as a mobilizing instrument

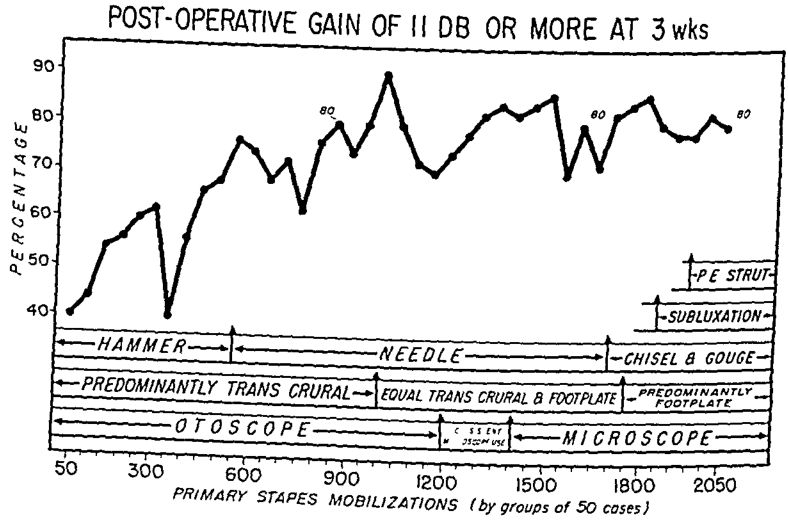

Fig 1

A study of the above graph reveals a stabilization in our results from the 800 case level to the 2,000 case level Approximately 80 per cent of the cases were achieving a significant gain three weeks following surgery This stabilization in results occurred in spite of the fact that we had changed our methods and techniques considerably from predominately the hammer and mobilizing needle to the needle alone, and later, to the chisels and gouges, from the otoscope to the microscope, from moderate mobility (Grade 2 motion without ligament tear or perilymph escape) to marked mobility (Grade 3 motion with ligament tear and perilymph escape), finally to subluxation routinely of all footplates (recently discarded)

From the 1,800 to 2,000 case level and beyond, we have been using the polyethylene strut placed directly on the shattered bluish footplate In selected cases of solid footplate fixation, we have been using the drill and the vein graft technique, after the method of Shea[2] (Vein graft series not sufficient to be statistically valid at this writing)

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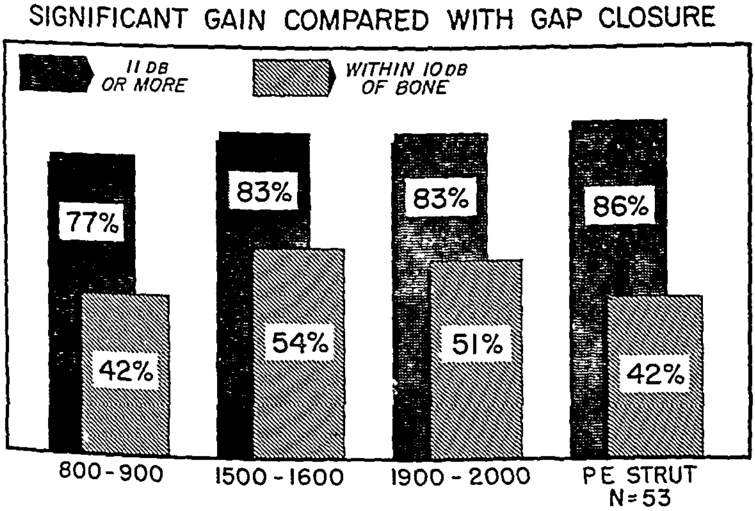

Fig 2

SIGNIFICANT GAIN COMPARED WITH TOTAL GAP CLOSURE

A random spot study in groups of 100 cases of significant gain compared with total closure of the bone-air gap failed to reveal any substantial difference in results (see Fig 2), regardless of the various techniques used during this interval of time

HEARING RESULT COMPARED WITH COCHLEAR FUNCTION

For this random spot study, achievement of the 30 db level in the three speech frequencies was considered to be a satisfactory hearing improvement (see Fig 3) Approximately 75 per cent of the cases with good cochlear function (A and B classification) closed their bone-air gap in the three speech frequencies to the 30 db level or better Approximately 60 per cent of all of the mobilization cases achieved a 30 db level, and about 40 per cent of the cases with poor cochlear function (C and D classification) achieved this level These percentages also remain fairly consistent from the 800 series to the 2,000 series, reconfirming the consistence in results in spite of the criteria of selection or the techniques used

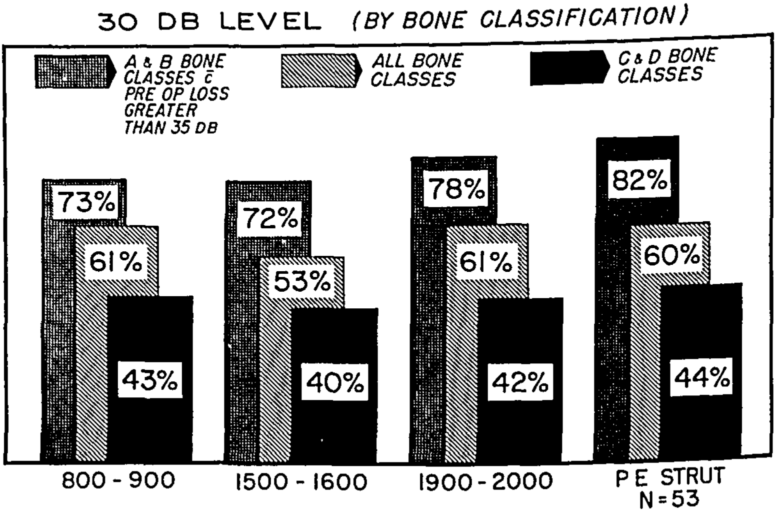

Fig 3

RESULTS BASED ON PERCENTAGE CLOSURE OF THE BONE-AIR GAP

A study of the last 100 cases reported in this series reveals approximately 85 per cent of the cases closed the bone-air gap, 25 per cent or more in the three speech frequencies, 70 per cent closed the bone-air gap 50 per cent or more, and 45 per cent closed the bone-air gap 75 per cent or more (see Fig 4) Since using the polyethylene strut in more and more cases, these percentages are gradually improving

The above series of statistical illustrations establish a trend, namely, that regardless of the technique used, if one achieves mobility of the footplate with ossicular continuity or with adequate substitution for this continuity, a fairly stable and constant type of healing result will be achieved three weeks following surgery

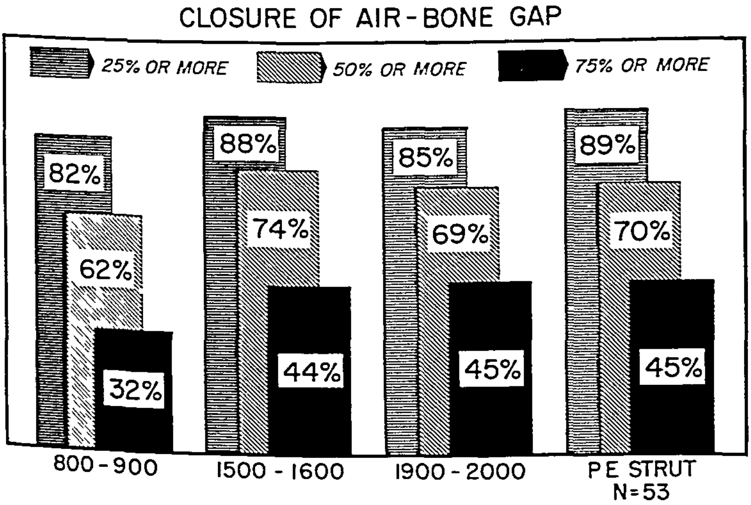

Fig 4

SIGNIFICANT GAIN AT THREE WEEKS COMPARED WITH OPERATING ROOM AUDIOMETRY

A study of the above illustration tends to establish that the better the result in the operating room, the more likely one is to have a significant gain three weeks following surgery, in a routine mobilization procedure (see Fig 5), however, approximately one-half of the cases that do not improve in the operating room, still achieve a significant gain at three weeks If there is a loss of 11 db or more in the three speech frequencies at the conclusion of surgery, only one out of five of this group shows a significant gain at the three weeks period

At the conclusion of a routine mobilization procedure, we rely more on what we see and feel than on what the operating room audiometry reveals If a polyethylene strut has been placed on a shattered bluish footplate, an immediate hearing improvement often does not occur This is apparently due to the lack of mass movement and an inner ear seal If a footplate is fenestrated or removed and a vein graft applied over the opening, an immediate significant gain, especially in the low tones is the usual response, apparently due to the presence of mass movement and an inner ear seal

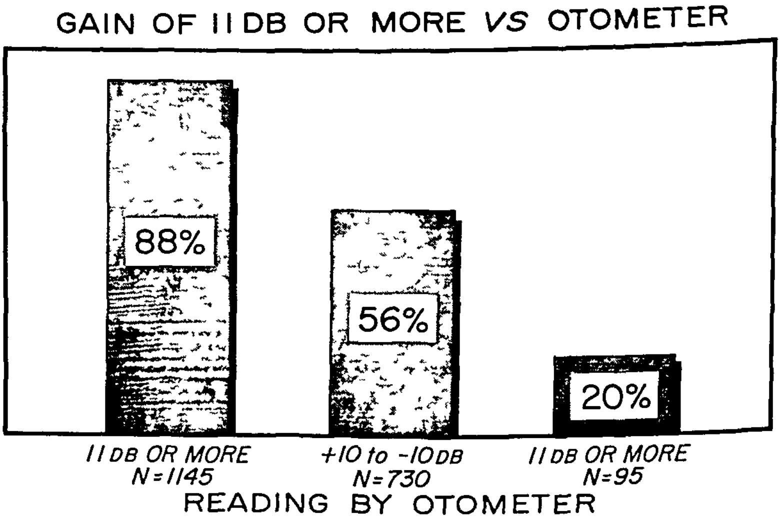

Fig 5

PERMANENCY STUDY

The above illustration reveals that 90 per cent of the cases that closed the bone-air gap 50 per cent or more three weeks following surgery, maintained that level at four months, 84 per cent of this group maintained their hearing level at one year (see Fig 6), therefore, of those cases that achieved their particular criteria three weeks after surgery, approximately 85 per cent are maintaining this criteria at one year

A detailed study of our long-term results beyond one year, is being made at this time Although I cannot give statistically valid figures at the time of this publication, it does seem apparent that the trend is toward gradual regression due to reankylosis

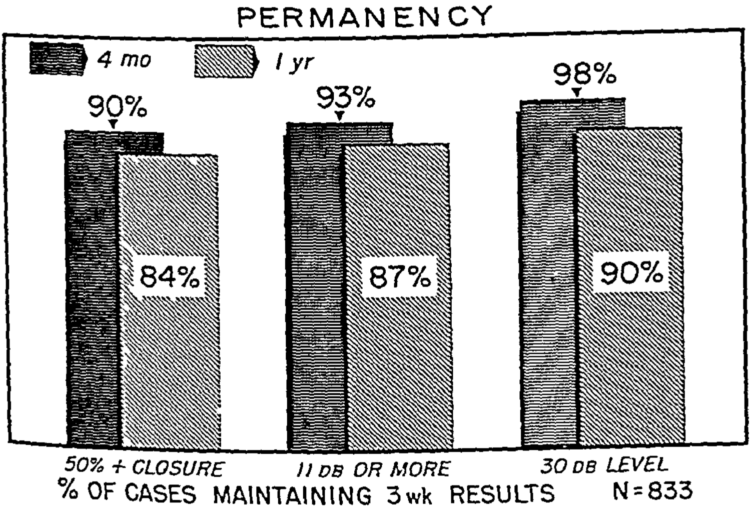

Fig 6

EARLY REANKYLOSIS

Case Report (Previously reported by Lindsay, et al[5]) A 44 year old woman with bilateral otosclerosis had a stapes mobilization performed in June, 1957 (see Fig 7) Mobilization was accomplished transcrurally and resulted in normal Grade 2 footplate motion without ligament tear or perilymph escape This resulted in a 35 db improvement in hearing (and complete closure of the bone-air gap) four months after surgery Eight months after surgery the patient died Section (see Fig 7) shows definite new bone formation in the annular ligament anteriorly

In spite of the early evidence of reankylosis in this case, there was no clinical evidence of hearing decrease, and the audiogram failed to reveal any evidence of hearing regression the operating room, still achieve a significant gain at three weeks If there is a loss of 11 db or more in the three speech frequencies at the conclusion of surgery, only one out of five of this group shows a significant gain at the three weeks period

At the conclusion of a routine mobilization procedure, we rely more on what we see and feel than on what the operating room audiometry reveals If a polyethylene strut has been placed on a shattered bluish footplate, an immediate hearing improvement often does not occur This is apparently due to the lack of mass movement and an inner ear seal If a footplate is fenestrated or removed and a vein graft applied over the opening, an immediate significant gain, especially in the low tones is the usual response, apparently due to the presence of mass movement and an inner ear seal

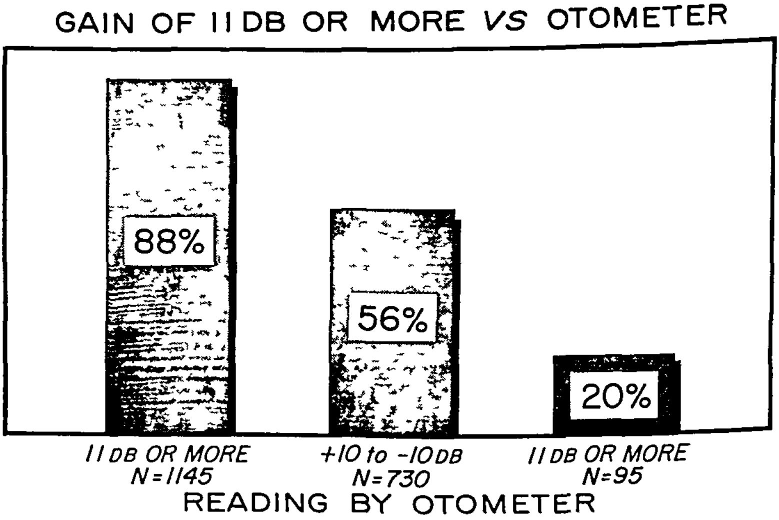

Fig 5

PERMANENCY STUDY

The above illustration reveals that 90 per cent of the cases that closed the bone-air gap 50 per cent or more three weeks following surgery, maintained that level at four months, 84 cent closure cases, a bone shift of 5.4 db in the three speech frequencies occurs. The better the result by air conduction, the greater the shift by bone conduction (see Table I).

SIGNIFICANT LOSSES (11 DECIBELS OR WORSE)

A study of the above illustration, indicates that as we gain more surgical experience, the percentage of cases that are made worse as a result of mobilization seems to be gradually decreasing (see Table II). This decrease is primarily due to fewer fractured crura and the use of substitution procedures in the event both crura are inadvertently fractured.

TABLE I

BONE CONDUCTION SHIFT

26-50% Closure	+0.85	$p = 0.23$
51-75% Closure	+2.64	$p = <0.001$
76-100% Closure	+5.47	$p = \ll 0.001$
11 DB Gain	+3.51	$p = <0.001$

The percentage of cases with inner ear involvement following stapes mobilization surgery seems to remain constant throughout our series. This is true in spite of the fact we have gone to the footplate much more as time went on. Approximately one-half of the cases that had further inner ear loss following mobilization surgery, were done by the transcrural approach without any direct manipulation of the footplate.

It would seem logical to assume, however, that in due time, refixation would occur in this case

Due to this gradual refixation trend, it seems logical that a higher percentage of permanent results following mobilization surgery can be achieved only through the use of a bypass, or substitution type, of surgical procedure, in order to avoid the active otosclerotic focus At the present time, we apply gentle transcrural manipulating pressures only in those cases with slight annular ligament involvement The cases mobilize readily by this indirect method In all other types of footplate fixation, we use a bypass or substitution technique, thereby avoiding the use of needles or chisels to fracture through the otosclerotic focus at the footplate margin If refixation of a case with slight ligament involvement does occur, a revision is performed, using a bypass procedure

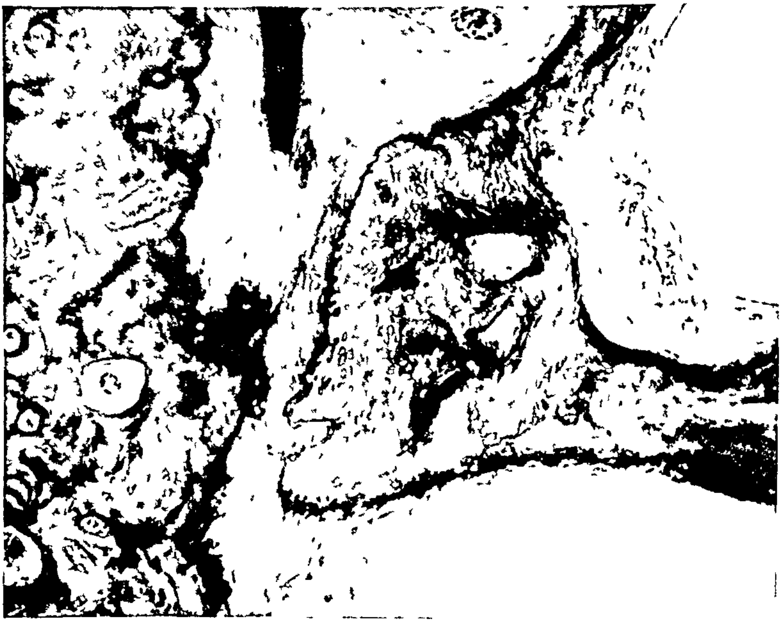

Fig 7

BONE CONDUCTION SHIFT

It is interesting to note that in the 76 per cent to 100 per

SEVERE INNER EAR LOSSES—MINUS 20 DECIBELS OR MORE

In this series of 2,000 mobilizations, there have been ten cases which developed a severe inner ear impairment Of these ten cases, six had total loss of hearing One of these six cases was the result of direct trauma in the operating room due to the use of the pneumatic hammer Surgery was routine and uneventful in the other nine cases An analysis of the other nine cases revealed that two were the result of infection, and the remaining seven were apparently vascular in type and developed from one week to as long as six weeks following surgery (see Table III) In each instance, the patient was hearing and suddenly developed severe tinnitus with or without vertigo, followed by loss of inner ear function Of these seven cases that had an apparent vascular accident, only three had direct footplate manipulation

TABLE IV

	PRE-OP				SURGERY							POST-OP				COMMENT
YEAR	AGE	BONE	AIR	VERTIGO	TECHNIQUE	OTOMETER	MOBILIZATION			VERTIGO	CRURAL FRACTURE	VERTIGO	INFECTION	HEARING	TIME	
							TC	FP	DEGREE							
56	35	C	43	0	O	-22	+		3	++		+	0	70	3 wk.	Gradual improvement to pre op. level in 2 mos. vasodilator ℞
56	63	A	40	0	O	-3	+		3	+		++	0	--	1 wk.	Continued vertigo despite vasodilator therapy
56	61	A	40	?	O	-15	+		4	+++	+	+++	+	77	3 wk	Continued vertigo despite vasodilator therapy
57	23	A	47	0	M	-14		+	3	0		+++	0	--	1 wk.	Revision mobilization on a congenital footplate fixation
57	40	A	50	0	M	+15	+		2	+	+	+	0	--	6 wk.	
'57	37	A	35	+	M	-15		+	3	+		0	0	--	3 mo.	
58	61	D	77	+++	M	0	+		2	0		+	0	—	1 day	
58	59	A	65	?	M	+23		+	4	+	+ strut	++	+	65	3 wk.	Bone dropped 20 db Air remained at 65 db.
58	62	B	45	+	M	0		+	3	0		+++	0	--	3 wk.	Vertigo for 6 mos despite vasodilator therapy
58	49	C	45	?	M	-2		+	4	0	+	0	0	68	11 wk.	

TECHNIQUE
- M Microscope
- O Otoscope

MOBILIZATION
- TC Transcrural
- FP Footplate

DEGREE
- 2 No ligament tear
- 3 Perilymph escape and subluxation (ligament tear)
- 4 Shattered footplate

TABLE II

SIGNIFICANT LOSSES
(MINUS 11DB OR WORSE)

	AIR LOSS	NERVE	TOTAL
1955	3	1	4 (1 50)
1956	15	5	20 (1'40)
1957	3	6	9 (1:90)
1958	2	4	6 (1.150)
	23	16	39

TABLE III

SEVERE LOSSES
(MINUS 20DB OR WORSE)

NERVE LOSS —— 10
  Total loss —— 6
  Partial permanent —— 3
  Returned to pre-op. —— 1
AIR LOSS —— 11
  Known crural fracture —— 9

21

volvement in this type of case (see Fig 8) What otosclerotic involvement is present is very minute and is located in the annular ligament itself Mobilization usually occurs readily by the indirect method Since the otosclerotic process is quite minute, the incidence of refixation in this type of case seems to be very low

Rosen[6] recently reported on the permanency of his first 100 successfully mobilized cases All were mobilized by the indirect (original) Rosen technique He stated that less than 15 per cent revealed regression five years after surgery I believe these cases were largely of the ligament type and, therefore, the low regression rate reported by the author

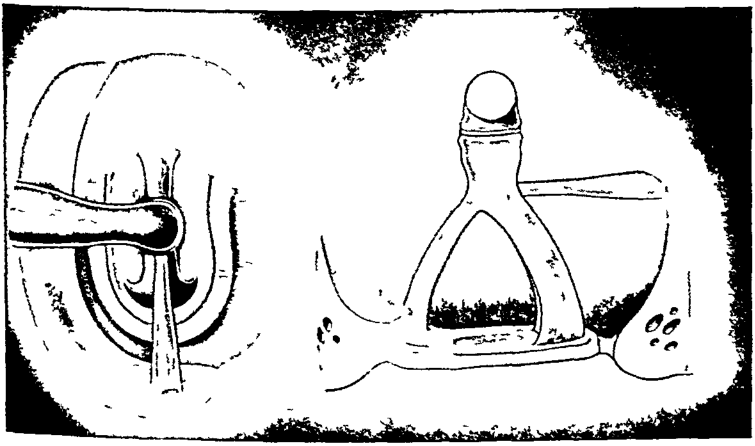

Fig 9

ANTERIOR FOOTPLATE FIXATION

If the footplate reveals an anterior type of otosclerotic fixation, transcrural pressure directed through the posterior crus will allow a slight amount of posterior mobility due to flexibility of the fixed anterior crus (see Fig 9) In this type of case, one may attempt transcrural mobilization If successful, either a fracture through the anterior otosclerotic process or a spontaneous anterior crurotomy will result If transcrural mobilization cannot be achieved, one may apply a

DETAILED ANALYSIS OF CASES WITH SEVERE INNER EAR LOSS

When one considers the number of cases reported in this series, the incidence of severe inner ear loss is not great (see Table IV) Because of this complication, however, one should not, except in most unusual circumstances, operate upon the better ear or operate upon both ears simultaneously

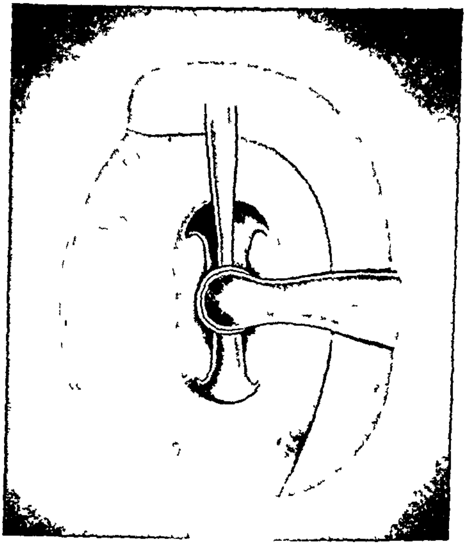

Fig 8

FOOTPLATE PATHOLOGY IN RELATION TO SURGICAL TECHNIQUE

We classify our footplate pathology into four main categories Ligament, anterior, bipolar and solid otosclerotic footplate fixation It has been our experience that we cannot accurately and consistently forecast the type of footplate fixation we may encounter by means of the preoperative audiogram

At the time of surgery, one must carefully analyze the type of footplate pathology that is present before proceeding with the act of mobilization

LIGAMENT TYPE OF FIXATION

It is difficult to visualize any evidence of otosclerotic in-tion applied by the transcrural approach reveals total and complete immobility. One does not notice any flexibility of either crus Mobilization in bipolar cases can be achieved only by fracturing directly through the active focus, and this results in either an anterior or posterior crurotomy Often both crura are inadvertently fractured

In our experience (see Fig 10), bipolar fixation cases tend to refix readily and are most unsatisfactory if one applies the usual manner of indirect or direct techniques of mobilization, consequently, we routinely remove the stapes crura and institute a polyethylene strut bypass procedure

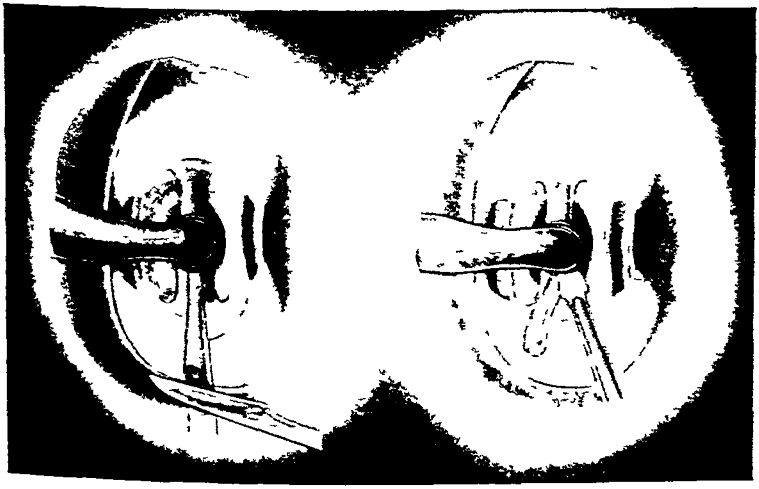

Fig 11

Severance of the stapedius tendon and separation of the inco-stapedial joint (see Fig 11)

Removing the stapes arch and crura (see Fig 12)

Measuring distance between the bluish central portion of the footplate and the incus (see Fig 13).

Insertion of the Polyethylene Strut

A previously prepared No 90 polyethylene strut of the correct length is carefully placed into position (see Fig 14) needle, chisel or gouge directly on the otosclerotic process at the anterior footplate margin It is known that many patients whose stapes were mobilized through the active otosclerotic process in years gone by continue to maintain their original hearing At present we do either the anterior crurotomy (Fowler technique[1]), or preferably, a bypass type of procedure in cases with anterior fixation The bypass procedure may be in the form of a posterior crural reapposition as advocated by Juers,[4] a tantalum wire prosthesis as advocated

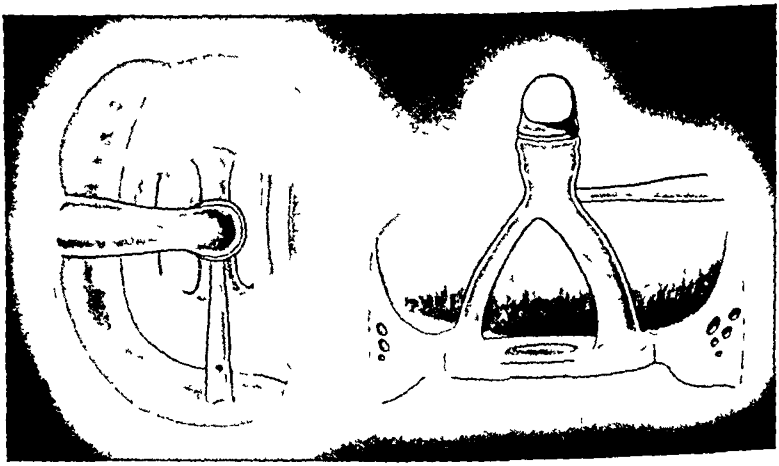

Fig 10

by Schuknecht,[3] a polyethylene strut and vein graft procedure, as advocated by Shea,[2] or a polyethylene strut placed directly on the bluish footplate, followed by shattering of the plate as preferred by the author At the present time we are doing oval window fenestrations with the vein graft, or gelfoam in all but ligament fixation cases This series is being done to compare the results with those obtained by placing the strut on the shattered bluish footplate The results of this series will be reported at a later date

BIPOLAR FIXATION

Bipolar fixation occurs more often than any other type in the author's experience In this instance, gentle manipula-

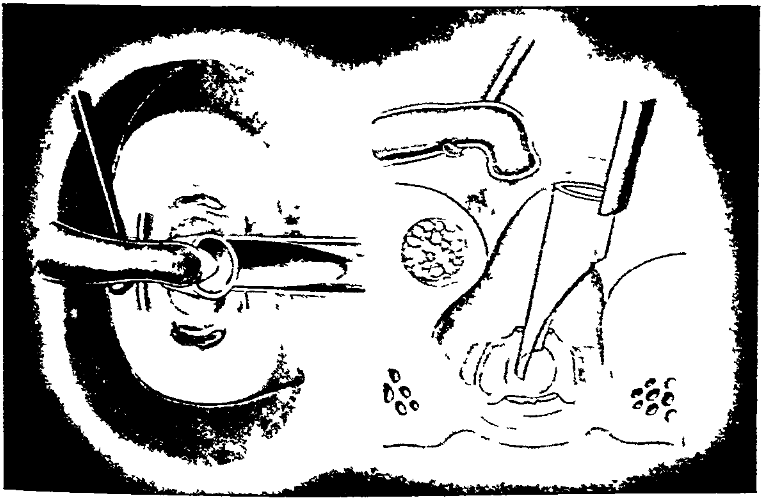

Fig 14

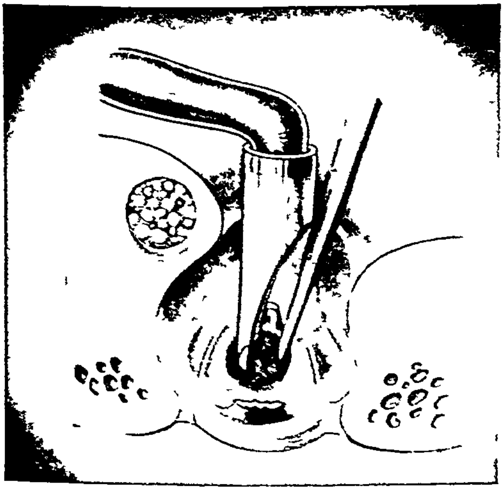

Fig 15

with adequate tension between the incus and the footplate, a small chisel is carefully used to shatter the bluish portion of the footplate in several locations (see Fig 15) Small pledgets of gelfoam may be placed about the footplate area, and the ear drum is replaced

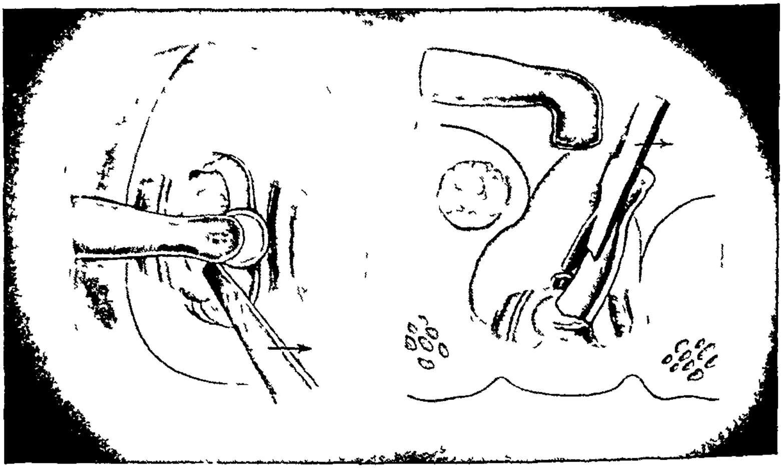

Fig 12

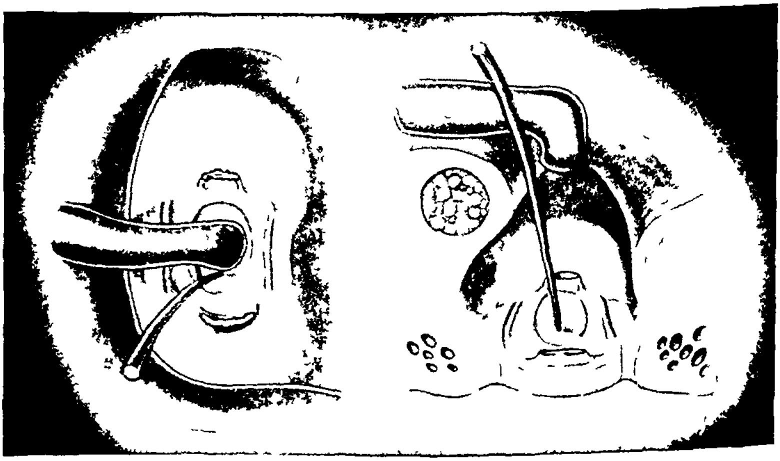

Fig 13

The length of the strut must be exact and a small hook is used carefully to lift the incus to allow the strut to take its position directly under the lenticular process The strut must be under slight tension between the incus and bluish portion of the footplate

SHATTERING OF THE FOOTPLATE

After the polyethylene strut has been placed in position

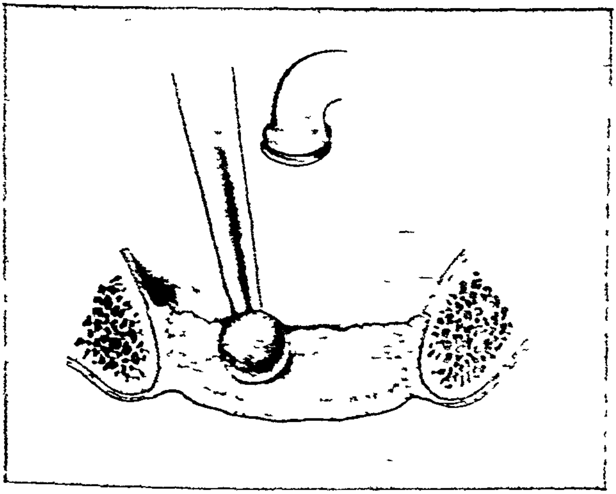

Fig 17-a

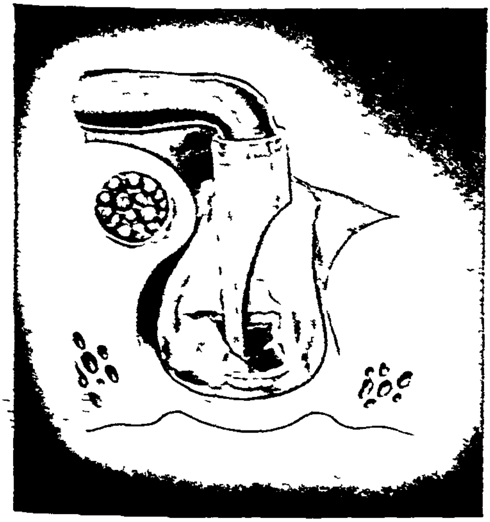

Fig 17-b

have found it to be a very satisfactory solution to this type of case (see Fig. 17-a and 17-b) Needless to say, this technique is technically difficult and not without risk to the inner ear

We owe a debt of gratitude to John Shea for his pioneering

We have had occasion to revise a number of previously mobilized cases. In most instances, the bluish portion of the footplate which was previously shattered remains shattered and movable Apparently, this portion of the footplate does not have the osteogenic regrowth tendency encountered in the otosclerotic focus

SOLID OTOSCLEROTIC FOOTPLATE FIXATION

Until recently when we encountered this type of fixation, we would attempt mobilization with a chisel and gouge If successful, rapid refixation frequently occurred In many instances, however, mobilization could not be attained, and the fenestration operation was carried out subsequently (see Fig 16), or if the patient was not suitable for fenestration, the continued use of a hearing aid was advocated

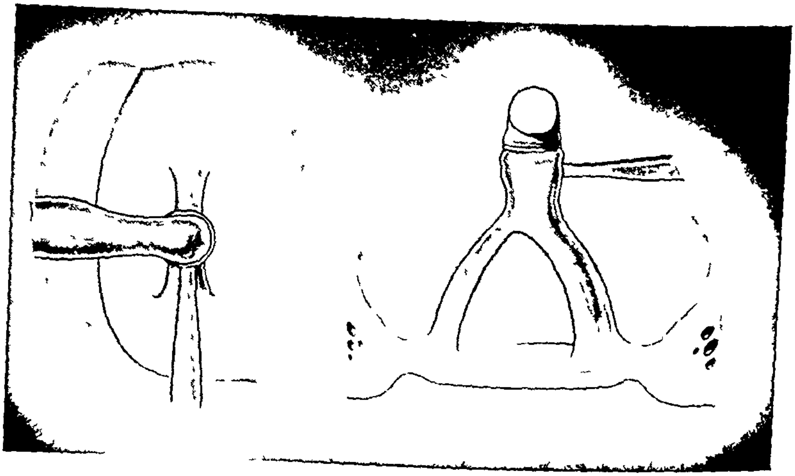

Fig 16

FENESTRATION OF SOLID FOOTPLATE

At the present time, we routinely use a diamond drill to fenestrate, or drill out the solid footplate as advocated by my brother[7] A vein graft (Shea[2]) or other substance, such as gelfoam is used to cover the oval window, and a polyethylene strut is placed into position Since using this method, we polyethylene strut is, indeed, most illuminating (see Fig 19) The polyethylene strut has resulted in our revisions being as successful as our original stapes mobilization cases If the failure of the original stapes mobilization cases was due to fractured crura, the polyethylene strut acts as a substitute If the cause of failure of the original procedure was due to refixation, the polyethylene strut allows a bypassing type of operation at the time of revision

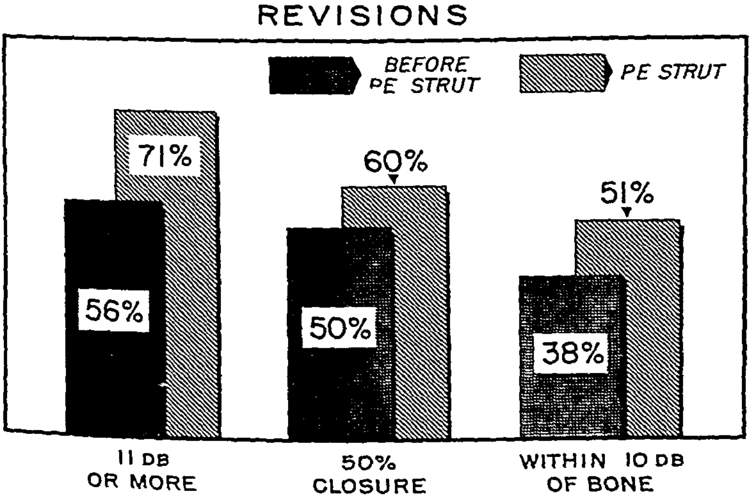

Fig 19

FOOTPLATE MOBILITY VS ULTIMATE HEARING RESULT

It seems apparent that whether one has a Grade 2 mobility (without tear of annular ligament or perilymph escape) at the conclusion of the operation, or one has a Grade 3 mobility (ligament tear and perilymph escape), there is little difference as far as the ultimate performance is concerned (see Fig 20) If any conclusions can be drawn, Grade 2 mobility has a slightly better chance of obtaining a significant gain, but no better chance of maintaining this gain than does the Grade 3 case, likewise, subluxation of the footplate does not seem improve the ultimate hearing result

The tendency of most surgeons doing this work is to mobilize in this field of substitution surgery for the stapes and stapes footplate He first presented the thought of substitution surgery some three years ago in a discussion at the meeting of the American Laryngological, Rhinological and Otological Society in Montreal [8]

FRACTURED CRURA VS POLYETHYLENE STRUT

The use of the polyethylene strut has allowed us not only to bypass the otosclerotic process, but if both crura are inadvertently fractured during a routine mobilization procedure, the polyethylene strut can be used as a crural substitute (see Fig 18) The accompanying illustration reveals that if both crura are fractured, the patient's chances of success are lessened by one-third The use of the polyethylene strut has altered this picture so that the result is now essentially the same in cases with fractured crura as it would have been had the fractures not occurred

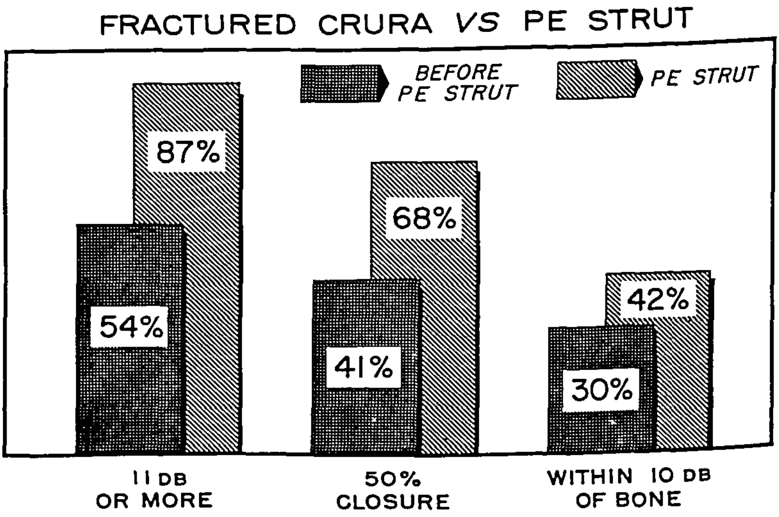

Fig 18

REVISIONS BEFORE AND AFTER THE POLYETHYLENE STRUT

A study of our revisions before and after the use of the sclerotic focus (oval window fenestration) will become more commonplace

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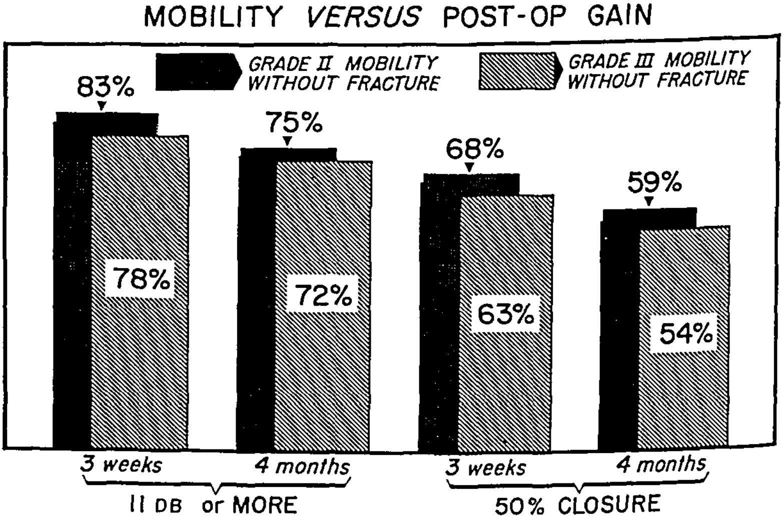

Fig 20

SUMMARY

What then are the trends in mobilization surgery?

The trend of the past has been represented predominately by indirect mobilizing pressures exerted through the crura

The trend of the present is represented by both direct and indirect mobilizing pressure on the footplate region

The trend of the future will be to continue those methods that have given successful results in the past (indirect mobilization in ligament fixation cases) In anterior and bipolar fixation, the future trend will be to avoid the active otosclerotic focus by using a by-pass procedure In extensive otosclerosis, removal of the footplate, together with the otosclerotic focus (oval window fenestration) will become more commonplace

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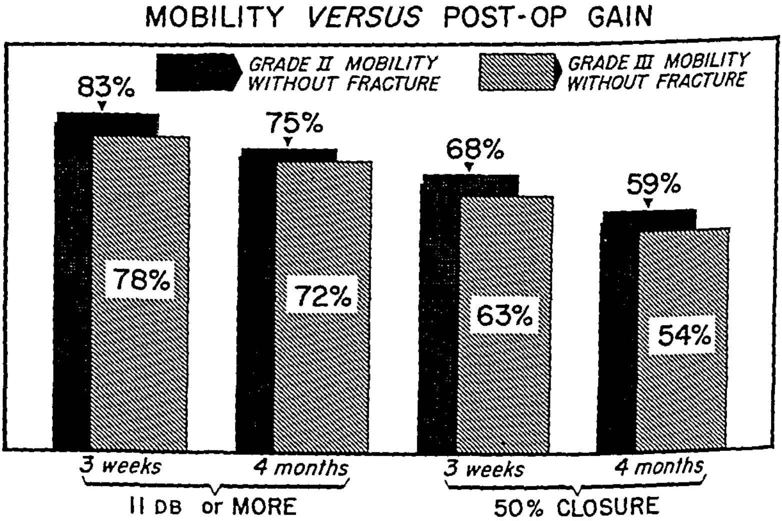

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The trend of the future will be to continue those methods that have given successful results in the past (indirect mobilization in ligament fixation cases) In anterior and bipolar fixation, the future trend will be to avoid the active otosclerotic focus by using a by-pass procedure In extensive otosclerosis, removal of the footplate, together with the oto-sized cellular mastoids, which did not look too different from each other The left mastoid did have thicker septal bone, but there was no destruction, and no indication of cholesteatoma formation, which did not explain why some of the material that was wiped from the canal appeared to be cholesteatoma pus Again she recovered, and returned at two to six month intervals with the same findings and the same favorable response to treatment

On the occasion of a visit 15 months later, it was noted that she had the same type of discharge in the left canal, but there was no discharge coming through the open anterior perforation in the left tympanic membrane This canal discharge had its usual viscosity and foul odor, and there was the same point of excoriated external canal skin Beneath the exudate on the posterior canal wall the bone was denuded and rough The exudate seemed typical of cholesteatoma There was no posterior or superior perforation of the tympanic membrane, and no discharge from the middle ear

Without enthusiasm, I cross-filed this as a cholesteatoma of the external auditory canal, thinking little of it as an entity, having seen her when there was mucoid discharge from the middle ear, and also considering her age of 70 and the possible trophic changes, nevertheless, I could not explain why there was no evidence of cholesteatoma in the middle ear, why the X-ray films showed no evidence of cholesteatoma of the mastoid antrum and why the impaired hearing was so alike in the two ears Since it would be much easier to think about this explanation tomorrow, and get on with the next patient today, this was painstakingly done and the situation adequately forgotten

Seven months later, Mr H W appeared with intact tympanic membranes, normal hearing, and a peculiar type of cerumen which adhered so closely to the right posterior inferior canal wall, that it took two treatments to remove it, following which rough exposed bone of the canal was visible I was fascinated to see that the medial end of the canal had undercut the tympanic membrane so much that the inferior part of the annulus tympanicus was relatively high in the canal The underside of the cerumenous plug and the thin

CHOLESTEATOMA OF THE EXTERNAL AUDITORY CANAL [*][†]

LESTER A BROWN, M D ,

Atlanta, Ga

On May 11, 1951, Mrs J C D , aged 70, complained to me of deafness and discharge in both ears Her story of ear trouble dated back 22 years, during which time she had received a diagnosis of "fungus" (supposedly of the ears), had become somewhat hard of hearing in the right ear, and had had the right ear washed out on one occasion, following which she had developed the only earache of her lifetime Other history was rather unimportant except that she had headaches and a productive cough

On examination, the right ear was found not to be discharging, although some amber fluid could be seen in the right middle ear through the intact tympanic membrane The left external auditory canal contained a considerable amount of heavy discharge, there was external otitis especially involving the inferior and posterior canal walls, and there was an anterior marginal perforation through which mucus was pulsating The hearing tests indicated conduction and nerve deafness similar in the two ears

Twelve days and two treatments later, there was no discharge from the left ear, no fluid could be seen in the right middle ear, and the hearing was clinically improved She was appreciative, remunerative, and procrastinative, returning for treatment seven months later, at which time again there was external otitis of the left ear with a large amount of material coming from the region of the anterior marginal perforation

X-ray films were a bit surprising in demonstrating moderate

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[*] Read at the Sixty-Second Annual Meeting of the American Laryngological Rhinological and Otological Society Inc Hot Springs Va March 11 1959

[†] From the Department of Otology and Rhinolaryngology Emory University School of Medicine

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nected with cholesteatoma of the external canal All patients were white

LITERATURE

Prior to the Twentieth Century, most of the literature on this subject was written in German Hessler's article must have been the classic In 1953, J J Biber presented his splendid article in which he gave a very complete summary of the works of his predecessors, whose collective opinions were that there is diversity of thought as to what causes cholesteatoma, where cholesteatoma starts, whether it has the right name, and whether there is any such thing as primary cholesteatoma of the external canal in the first place

So far as I know, the most recent article was written by Col Byron G McKibben, U S A, and published in the May, 1958, issue of the *Archives of Otolaryngology* In it he described one case which occurred in a Negro Just last month, I received a cordial letter from the Colonel in which he stated that he feels now that he might prefer a split thickness skin graft in the stenosing external canal rather than the modified radical mastoidectomy

DESCRIPTION

There are certain definite physical characteristics to be found in the cholesteatomatous, human auditory canal To the otolaryngologist, this is such a common channel of investigation, that the details of its shape are rarely even considered The circuitous route to the tympanic membrane, probably so shaped for protection, begins with the springing forward of the conchal cartilage, which is overlapped by the backward inclination of the tragal cartilage This barrier is quickly eliminated by inserting the aural speculum If one then should look directly through the speculum on a horizontal line, without moving the line of vision or the speculum, he would note that the tympanic membrane is usually invisible in its anterior one-fourth, the reason being the backward bulging of the bone of the anterior canal wall, just behind the temporomandibular joint, which we might designate as the *bulge anris* The lower one-eighth to one-fourth of the tympanic membrane covering of the rough bone resembled the matrix that covers the bone of the mastoid antrum, in cases of cholesteatoma

One-and-one-half years after this, Mr J T F came in with much the same situation as Mr H W , except that his canal was more deeply eroded with exposure of mastoid cells I decided that it was time to quit waiting until tomorrow to think

Since 1951, nine such patients have been observed by me, each with his individual characteristics, but all having one thing in common—an area in the external auditory canal where the bone is covered by a thin, white, sickly-looking membrane, from which seems to come a cholesteatoma type of discharge, complete with heavy flakes and foul odor

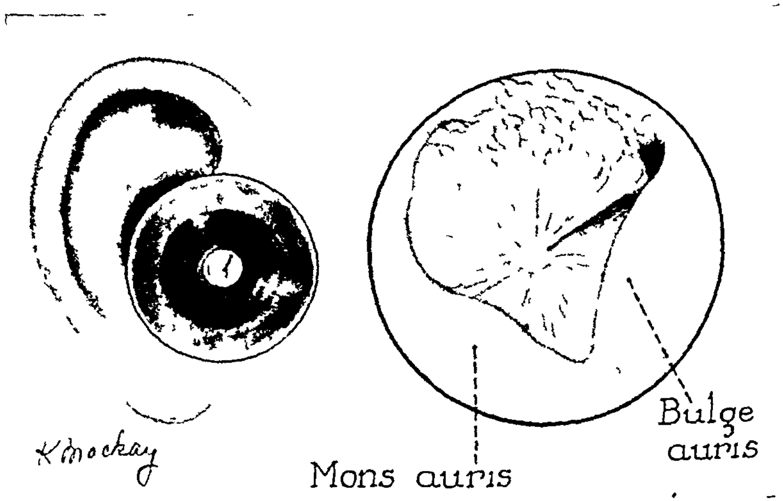

Fig 1 The right external auditory canal as it often appears The complete membrane is rarely seen

There were four males and five females The ages ranged from 19 to 77 The left ear was affected seven times, the right twice The most consistent accompanying condition was the noticeable vasomotor rhinitis with or without the productive bronchiectatic cough, which was found in six of the nine patients This would be a point in favor of the theory proposed by Van Canaghem, Harpman, and others I have not seen where this condition could be directly con-be undercut a full ten millimeters, even to the extent of exposing mastoid cells, in which instance the inferior aspect of the annulus appears to be raised to the middle of the medial end of the external auditory canal

The surface of the bone of the lesion is irregular When the thin, unhealthy appearing epithelium which covers this is removed, the underlying bone often presents a shiny appearance, and there may be a small amount of bleeding An exposed mastoid cell is always covered by what appears to be its individual mucous membrane lining I have never seen fluid or cholesteatoma in one of these cells, and I have never entered one of these cells in search of either

Although some of the previous writers have considered the anterior canal wall as the favorite site for the focal point of this lesion, in my cases, the floor and contiguous posterior wall have most often suffered

Other findings of this condition are

1 A heavy cerumenopurulent, foul aural discharge which is not attended by as much tenderness and pain as is found in ordinary external otitis (pain and tenderness are not common)

2 An intact tympanic membrane, or at least one in which there is no obvious connection with the external canal lesion

3 The hearing in the affected ear is more in keeping with the hearing of the unaffected ear, whether or not this be normal, than with a hearing curve that indicates involvement of its conduction mechanism

4 X-ray findings not indicating cholesteatoma of the middle ear or mastoid

Tissue for microscopic examination has been recovered from five of these nine patients Local anesthesia by injection is used Often, the canal lesion is covered by a cerumenopurulent epithelial plug which is fitted into the bony excavation When this is removed, the edges of the lesion may be clean, but, as a rule, there is a border of granulations

The biopsy is obtained by elevating the granulomatous edge, is hidden by a more or less mounding up which we might call the *mons auris* Medial to the mons, the bony canal declines to form a sulcus on the lateral side of the annulus tympanicus, inferiorly, therefore, the most consistently visible part of the tympanic membrane from a direct horizontal view is the posterior superior segment

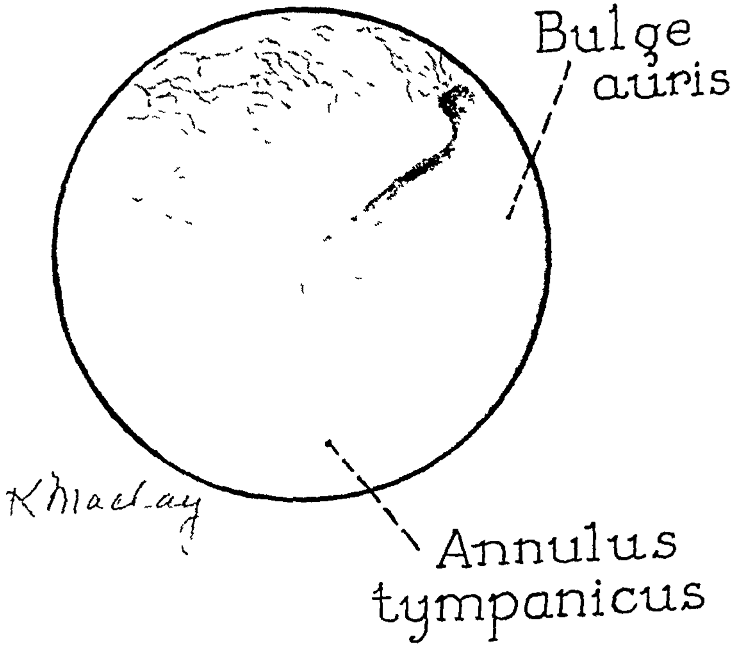

Fig 2 The size and shape of the normal external auditory canal varies The mons may not be present but the bulge is almost always seen

The most common variation is the height of the mons, which in some cases (far less than 50 per cent in my experience), may be hardly elevated at all Then the canal is large, and the tympanic membrane can be seen in its entirety except for a bit of the anterior part of the annulus Such an auditory canal may be thought of as the *mobilizer's delight*, for obvious reasons Seldom does the normal canal undercut the annulus tympanicus more than perhaps two millimeters, but, where there is cholesteatoma of the external canal, the annulus may patient with this disease is considered to have simple detritus for which the usual treatments are administered

TREATMENT

Generally speaking, conservative treatment is preferred The patient can be made asymptomatic by cleanliness He can help by using a simple cleansing irrigation such as the boric acid-alcohol solution, but, an occasional professional debridement is necessary No operative procedure has been carried out in any of these patients Should an operation be advised, an extensive modified radical mastoidectomy with removal of all mastoid cells would be necessary I cannot conceive of any advantage Even though there does not seem to be a tendency for the eroded bone to heal, progression of the disease is significantly slow and splendidly inconsequential

SUMMARY

1 There are reasons to believe that *cholesteatoma of the external auditory canal* is an entity

2 A general report covering the pertinent findings observed in a series of nine patients has been presented

3 The most important finding is erosion of the bony floor of the external auditory canal

4 Treatment has been conservative

5 The cause is unknown

"Finally brethren whatsoever things are true honest just, pure lovely of good report if there be any virtue and if there be any praise think on these things ' (Philippians 4 8) So said the Apostle Paul

I express my appreciation to pathologists H Vincent Bell, M D, and Lester Forbes M D, Georgia Baptist Hospital, Atlanta, Ga, and to the medical illustrator, Miss Kathleen MacKay, and photographer, Joe T Jackson, Emory University Atlanta, Ga, for their valuable aid in preparing this article

including, if possible, some of the epithelium that covers the lesion The microscopic findings have been quite uniform Sections from the margins show heavy, limited epithelium reported as hyperkeratinization Those from the epithelium overlying the rough bone show connective tissue dermis with a covering of thin epidermis, on which is amorphous desquamation, which is affectionately known to us as *gunk* Histologically, this cannot be differentiated from the gunk that is seen overlying the epithelium of an inclusion cyst, except that the latter is more tightly packed Indeed, the epithelium of the canal lesion does not differ primarily from the normal skin of the bony canal wall In only one case did the pathologist question activity enough for him to advise rebiopsy at an appropriate time

COMMENT

Granting that there is at present no known cause for cholesteatoma of the temporal bone, it may be that cholesteatoma of the external auditory canal is an entity which results either from local periosteitis with subsequent superficial devitalization of the underlying bone, or the reverse in which, for some reason unexplained to me, the tympanic bone becomes unhealthy It may be that the temporal bone is subject to irreversible damage in infections, because of its cellular makeup It may be that the invagination of the epithelium to form the external auditory canal makes this a type of potential inclusion cyst which does not withstand the stress of long standing infection I favor the speculative periosteitis, but I am not convinced that it necessarily develops from the discharge that flows over it from otitis media and mastoiditis through a perforated tympanic membrane

This subject initiates a rather important question According to current gossip, the cholesteatomatous cavity of the mastoid bone becomes larger because of the pressure brought to bear on the bone by the cholesteatoma In the external canal, there is bone erosion, but there is no obvious pressure Could the gossip be wrong?

Contrary to a prevailing opinion, I do not think that this condition is extremely rare More likely it is that the average

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LARYNGOSCOPE.

VOL LXIX SEPTEMBER, 1959 No 9

THE CRICO-ARYTENOID JOINT

A Diarthrodial Articulation Subject to Rheumatoid Arthritic Involvement*†

IRA A POLISAR, M D ,

Brooklyn, N Y

In 1952 the author's attention was first drawn to a clinical situation which was unique to him At that time, and until December, 1955, he was not aware of this clinical entity having been described in the American otorhinolaryngological literature

Since 1952 he has seen a total of six cases, and since December, 1955, when Montgomery, Perone and Schall[29] wrote on the subject, two other articles have appeared in the American literature[37, 40], and in all probability there will be several more in the near future

The purpose of this endeavor, therefore, is not to belabor the subject further, but to make the following points

1 That what is "new" to one, may well be "old hat" to others, particularly where the others are intellectually more broadened and/or intelligent enough to recall, or re-explore, basic texts

2 That there is really very little "new," if one takes the trouble to search the old literature particularly in our special-

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*Submitted as Candidate's Thesis to the American Laryngological Rhinological and Otological Society Inc 1958

†From the Division of Otolaryngology Department of Surgery State University of New York Downstate College of Medicine Brooklyn N Y and the Department of Otolaryngology Long Island College Hospital Brooklyn N Y

Editor's Note This manuscript received in The Laryngoscope Office and accepted for publication Feb 9 1959

ty, that of the Germans and English, during the latter half of the last century and the first decade of this century

3 That it cannot help but stir up a great sense of admiration and respect for some of our forebears in otorhinolaryngology when one sees their remarkably astute observations and clinical acumen at a time when their armamentarium must have been exceedingly crude compared to currently available aids in diagnosis

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Rather than present all six cases in the usual style, I take the liberty of relating, in narrative form, my experiences with the first case I encountered, interspersing history and physical findings with the thinking (and lack of it) which transpired. The other case histories will be reported in the usual, more brief form.

Case 1. G. M., a 57 year old white male, was admitted to the Brooklyn Veterans Administration Hospital on Nov. 17, 1952, with a chief complaint of difficulty in breathing of one week's duration. This had been getting progressively worse up to the time of admission. For several weeks prior to this there had been slight hoarseness. There was no pain and no dysphagia. There had been no weight loss and no fever.

His past history revealed occasional episodes of "asthma" of about ten years duration for which he had been treated irregularly and at widely separated intervals. Included in his past history was an admission to another hospital eight months before. The only available clinical record from that institution indicated that he had been admitted there on March 27, 1952, because of 'difficulty in respiration' following an upper respiratory infection. Apparently direct laryngoscopy was performed, the details of which were not included in their resume. There was no indication that this had been preceded by indirect laryngoscopy, though in all probability it had been done, nor were findings on this procedure noted. However, their report did state that "pathological microscopic examination (of tissue presumably removed at laryngoscopy) was reported as negative for malignant cells." They also reported that sputum was negative for acid fast bacilli. The patient was discharged on April 26, 1952, for follow up at their clinic. (In the light of my own subsequent experience this previous hospital admission is a very revealing and important part of his past history and will be dwelt on subsequently.)

Of further importance in his past history was the absence of any diseases suggestive of diphtheria or typhoid fever There was no history of trauma to the neck and no history of thyroid or other anterior neck surgery The patient denied having ever had any venereal disease, and there was no history of joint pains or arthritis

Physical examination on admission revealed a well developed, well nourished white male with moderate inspiratory stridor, moderate apprehension, but no cyanosis The voice was only slightly hoarse Blood pressure 146/84 Temperature 98 8° F Pulse 88 Auscultation revealed wheezes throughout the chest but no moist or dry rales Remainder of physical findings were negative except for indirect laryngoscopy, which revealed a slit like glottic chink, with the vocal cords "being held in adduction" by a flat adhesive band running across the rima glottidis from the mid portion of the free edge of one cord to the free edge of the other This band of tissue was about 2 to 3 mm in width anteroposteriorly

With these findings on mirror laryngoscopy it was easy to reason that a traumatic direct laryngoscopy had been performed at the time of his earlier hospital admission, resulting in denudation of both cords with subsequent formation of a synechia or adhesion and his present resultant respiratory difficulty One wondered what tissue had been biopsied or removed, and why, since (as noted) the report from that hospital merely stated 'negative for malignant cells" One readily visualized a heavy-handed, not quite necessary laryngoscopy by some unidentifiable inexperienced colleague—wisely kept these thoughts to himself—and made plans to "fix the patient up in short order"

Meanwhile, the following laboratory and X ray data came through Complete blood count was normal Serological test for syphilis was negative Urinalysis normal Chest X ray revealed no evidence of cardiovascular, pulmonary, pleural or mediastinal pathology

Approximately 36 hours after admission the patient was taken to the operating room for direct laryngoscopy for lysis of the laryngeal synechia The Jackson anterior commissure laryngoscope was introduced with the beveled tip in the anterior commissure bowing both cords outward anterior to the synechia (which was in the mid portion of the middle third of the cords) and putting this adhesive band on the stretch With a laryngeal knife the synechia was severed without difficulty

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THE CRICO-ARYTENOID JOINT

A Diarthrodial Articulation Subject to Rheumatoid Arthritic Involvement *†

IRA A POLISAR, M D ,

Brooklyn, N Y

In 1952 the author's attention was first drawn to a clinical situation which was unique to him At that time, and until December, 1955, he was not aware of this clinical entity having been described in the American otorhinolaryngological literature

Since 1952 he has seen a total of six cases, and since December, 1955 when Montgomery, Perone and Schall[29] wrote on the subject, two other articles have appeared in the American literature[3, 40] and in all probability there will be several more in the near future

The purpose of this endeavor, therefore, is not to belabor the subject further, but to make the following points

1 That what is "new" to one may well be "old hat" to others, particularly where the others are intellectually more broadened and/or intelligent enough to recall, or re-explore, basic texts

2 That there is really very little "new, if one takes the trouble to search the old literature, particularly in our special-

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*Submitted as Candidate's Thesis to the American Laryngological Rhinological and Otological Society Inc 1958

†From the Division of Otolaryngology Department of Surgery State University of New York Downstate College of Medicine Brooklyn N Y and the Department of Otolaryngology Long Island College Hospital Brooklyn, N Y

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It was now evident that we were dealing with a case of bilateral crico-arytenoid fixation and what other morbid process besides an "arthritis" could be responsible. In order to have an arthritis there had to be a joint, and while I had many times before used the term 'crico-arytenoid joint,' I had never thought of this area as a true joint.

It was also evident that in all probability this patient's crico-arytenoid joint had been involved in a slowly progressive pathologic process of a low grade inflammatory or degenerative nature possibly of many years' duration. It was felt that it was quite conceivable that this condition existed at the time of his prior hospital admission eight months before

> because of 'difficulty with respiration." It was also reasonable to assume that his synechia would never have developed isolated in the middle of the cords as it was (rather than in the form of an anterior webbing) were it not for the fact that even then his cords were relatively immobile *in adduction*; furthermore, harking even farther back it was my feeling that in all probability this patient's "asthma" of ten years' duration may have been rather an inadequate glottis. (One recalls the aphorism of Chevalier Jackson: 'All is not asthma that wheezes.') These feelings were borne out by several things: *1.* that in going over his past history it became evident that most of his "asthmatic attacks" were almost always concurrent with upper respiratory infections; *2.* that there had been little or no relief from the usual anti-asthmatic drugs; *3.* the fact that during his current hospital admission a thorough allergy work-up revealed no evidence of positive reactions to any significant allergen. The Allergy Service stated that they felt he was 'a non-reactive asthmatic'; *4.* that from the time of his tracheostomy and all through his subsequent course in the hospital, for a period of almost seven months, he had no further asthmatic attacks."
>
> It was suggested to the patient that he have an arytenoidectomy so that he might be rid of the tracheotomy tube. It took him a number of months to agree to this. During this time the patient was put on a course of Cortisone therapy and the larynx was re-examined periodically. No motion of vocal cord or arytenoid was seen and consequently, it was not until June 9, 1953, that surgery was performed. On that date a right arytenoidectomy was done via a laryngofissure approach according to the method described by DeBord.[11] His postoperative course was uneventful. Incidentally, fortunately the previous synechia had not reformed and the cord edges were smooth. On July 20, 1953 the glottic chink measured about 5 mm. at the posterior commissure with the right cord about midway between complete abduction and adduction. On phonation the left arytenoid and cord adducted perhaps a millimeter or two but did not abduct at all. Consequently the airway was adequate and there was a quite serviceable slightly breathy voice. The patient was decannulated. He has had no known difficulty since.

This is what was learned. Given a patient with dyspnea in whom the laryngeal mirror reveals a bilateral mid-line position of the vocal cords, the diagnosis of abductor paralysis is not justified, *a.* if there is no history of neck trauma; *b.* if there has been no thyroid or other low anterior neck surgery; *c.* if there is no chest lesion (even though it would be difficult to see how a chest lesion could involve both right and left recurrent nerves without other symptoms or signs); *d.* if there is no history of diphtheria or typhoid fever; *e.* if there is no history or serologic evidence of syphilis; *f.* if there is no evidence of other cranial nerve involvement besides the vagus, since it is hardly possible for any kind of central lesion to involve the nuclei or tract of the Xth nerve and no other.

These considerations alone should be sufficient to make one practically certain that there is fixation of the crico-arytenoid joint, rather than a bilateral abductor paralysis.

The final diagnosis can be unequivocally established by making, via direct laryngoscopy, the "passive mobility test" described by C Jackson[21] In paralysis the cords are flaccid and are easily abducted passively In fixation, the anterior two-thirds may be forcibly bowed slightly, but the vocal processes remain close together and parallel to one another, and the arytenoid prominence is relatively immobile

ANATOMY

Unfortunately, not all standard texts on human anatomy describe the crico-arytenoid joint *per se* In describing the cricoid and arytenoid cartilages, their articular facets are mentioned, however, Todd,[18] in the section titled "Articulations, Ligaments and Membranes of the Larynx" gives the following description

> "Crico arytenoid Joints Each of these joints has a ligamentous capsule lined by a synovial layer The cricoid articular surface is convex, whereas that of the arytenoid is concave, both are elliptical in form and they are applied to each other so that the long axis of the one intersects or crosses that of the other at an acute angle In no position of the joint do the two surfaces accurately coincide—a portion of the cricoid facet is always left uncovered The capsule of the joint is strengthened behind by a band, which is inserted into the postero medial part of the base of the arytenoid cartilage and plays an important part in the mechanism of the joint it effectually arrests excessive forward movement of the arytenoid cartilage The movements which take place at the crico arytenoid joints are gliding and rotatory During easy, quiet breathing the arytenoid rests upon the lateral part of the cricoid facet It can glide upon the cricoid facet and pass toward or from the medial plane and its fellow of the opposite side In the rotatory movement the arytenoid cartilage revolves around a vertical axis, by this movement the vocal process is swung laterally or medially so as to open or close the rima glottidis"

The author goes on to describe a more or less rudimentary joint between arytenoid and corniculate cartilages, with a capsule but with no synovial lining

Maximow and Bloom[illegible] have this to say about joints and synovial membranes

> "Bones are joined to one another by connective tissue structures which permit varying degrees of movement between the adjoining bones" (or as in our subject, cartilages) 'Such structures are called joints or articulations These present extreme variations in character which depend primarily upon the type of bones which are joined and the varying degrees of motion permitted by the articulation Thus, in some cases as in the skull, the joints are immovable and the connected bones are separated by only a thin connective tissue layer the sutural ligament

Other joints are slightly movable such as the intervertebral articulations Here the succeeding vertebrae are joined to one another by dense fibrous tissue and cartilage Still other bones are freely movable upon one another, and here the bones are completely separated by cartilage and fibrous capsules'

Articulations in which there is little or no movement are called synarthroses Of these there are three types if the connection between the bones is of bone it is called a synostosis if of cartilage, a synchondrosis and if of connective tissue a syndesmosis Joints which permit free movement of the bones (or cartilages) are called diarthroses

We have thus established, it seems fair to state that the crico-arytenoid joint is actually a true diarthrodial articulation It is composed of two cartilages (which, incidentally with advancing age, ossify in an orderly sequence, according to Pressman and Kelemen[illegible]) which move freely on each other there is a definite joint capsule between them each has an articular surface each surface and the capsule is lined with synovial membrane yet nowhere has the author seen this joint listed among diarthrodial articulations

In diarthrodial joints there is a cavity The walls of the joint cavities are composed of a dense connective tissue whose cells are irregularly distributed and seldom suggest epithelium in arrangement Occasionally small amounts of cartilage as well as all transitions between the cartilage cells and the joints or synovial cells can be found

Articular surfaces are composed of or covered with hyaline cartilage Where opposing cartilages touch they are not covered with dense connective tissue, but at their bases a small area of perichondrium is reflected backward into the membrane of the joint capsule Articular cartilages, as is the case with most of the cartilage of the body contain no blood vessels

The synovial membrane lining the articular surfaces and capsule as a continuous unbroken lining may be thrown into either temporary folds which depend on the position of the joint, or they may form permanent villi which project into the joint cavity There are no villi shown in any of the illustrations in this paper however, Pearson[3] in a recent article

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Many of the points of anatomical interest noted above may be seen in Figs 1, 2 and 3 The crico-arytenoid joints of a dog and a cat are shown for comparison in Figs 4 and 5, respectively

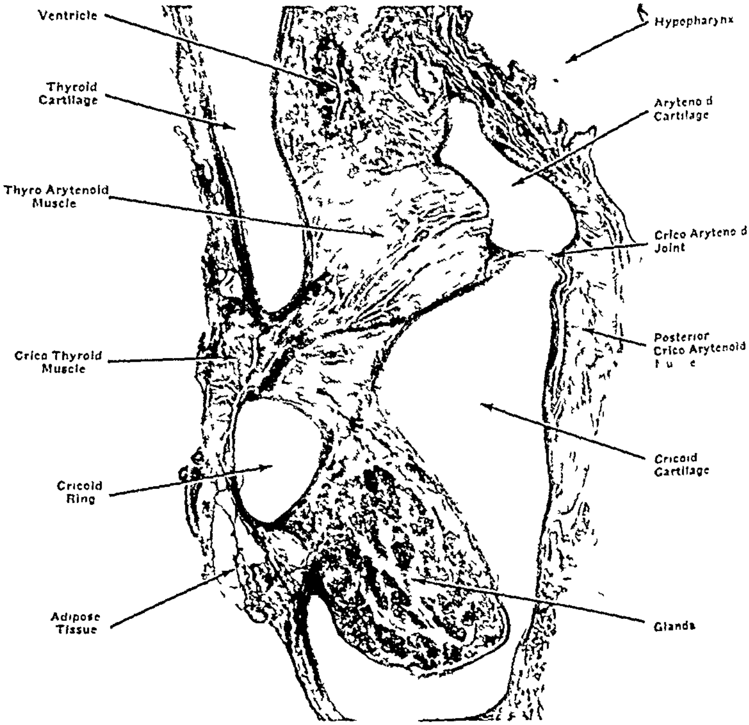

Fig 1 Microphotograph (X7) of sagittal section of larynx of a nine-month-old infant showing the crico-arytenoid joint

Having learned as a result of my first case (v s), to consider this a true joint, subject to arthritic changes and resultant fixation, I should like to have been able to report that my subsequent experiences with this syndrome were not so breathtaking (if I may be permitted this play on words) to

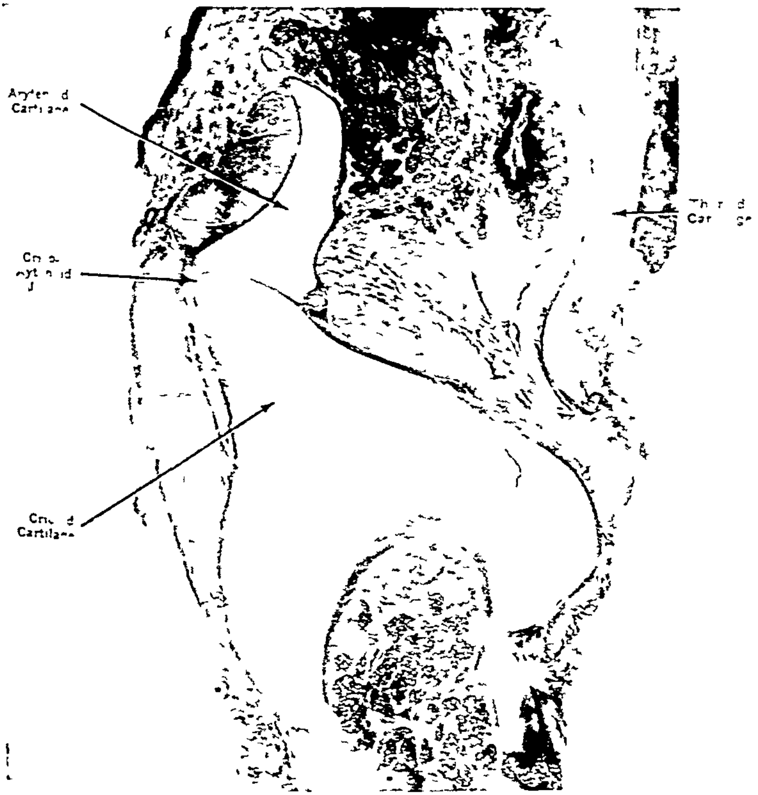

Fig 2 Microphotograph (X9) of sagittal section of larynx of a nine-month-old infant showing the crico-arytenoid joint at about the mid-portion of the joint Compare with Fig 3 which is a similar section from same specimen but about 1 5 cm more medial

either the patient or myself, but unfortunately, as will be seen from the following case reports, this was not universally true

ADDITIONAL CASE REPORTS

Case 2 J D a 58 year old white male had been admitted to the Surgical Service of the Brooklyn Veterans Administration Hospital on Dec 3 1952 for excision of a ganglion of the right wrist On admission it was noted that he was wearing a tracheotomy tube through which he breathed and which he expertly occluded with his finger when he wanted to speak Otolaryngologic consultation was requested After excision of the ganglion he was transferred to the Otolaryngology Service on Dec 19 1952

Past History Strenuous efforts to establish the reason for his tracheotomy resulted only in our finding that in July 1945 at another hospital he had had this tracheotomy performed because of increasing dyspnea

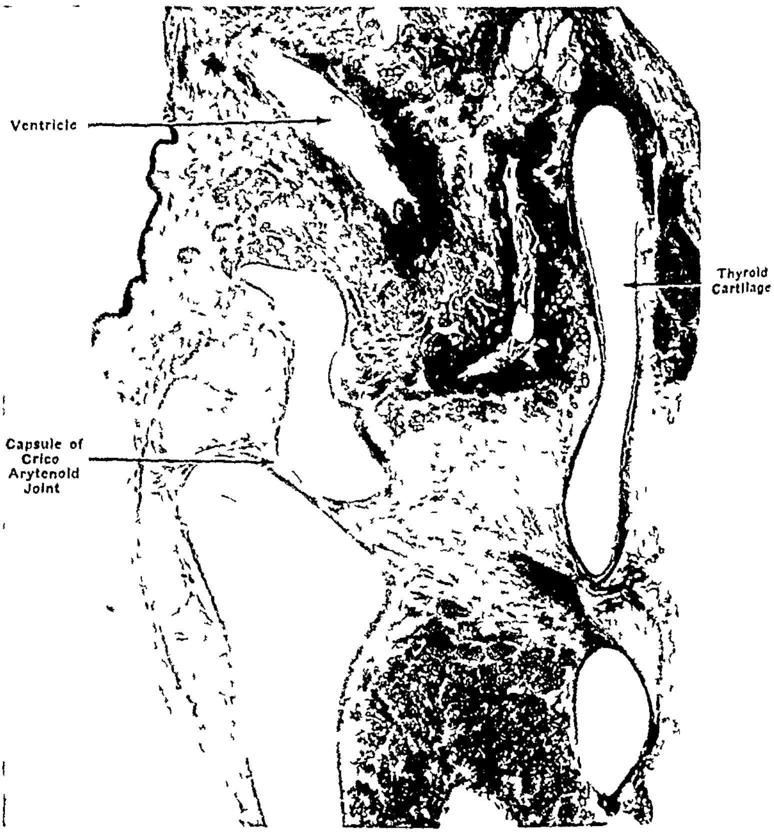

Fig 3 Microphotograph (X9) of sagittal section of larynx of a nine month-old infant This section is about 1 5 mm more medial than that in Fig 2 and shows tangentially the medial portion of the joint capsule as compared to the slit-like joint space in Fig 2

over a period of about two months Other than the tracheotomy he remembered no specific therapy and did not recall having been told exactly why he needed to wear this tube Repeated efforts on our part to obtain hospital extracts or summaries were unsuccessful It is noteworthy that for a period of seven and a half years from July, 1945, to December, 1952, this patient worked as a taxicab driver in a bustling metropolis, and was apparently socially and economically adequate

The remainder of his past history was noncontributory There had been no diphtheria or typhoid fever He denied having had venereal disease There was no history of trauma to the neck There had been no thyroid or other anterior neck surgery There was no history of arthritis or rheumatism

Review of Systems was negative

Physical Examination revealed a well developed well nourished white male, lucid and cooperative Blood pressure 116/78 Pulse and respiration normal A No 6 tracheotomy tube was in place Indirect laryngo

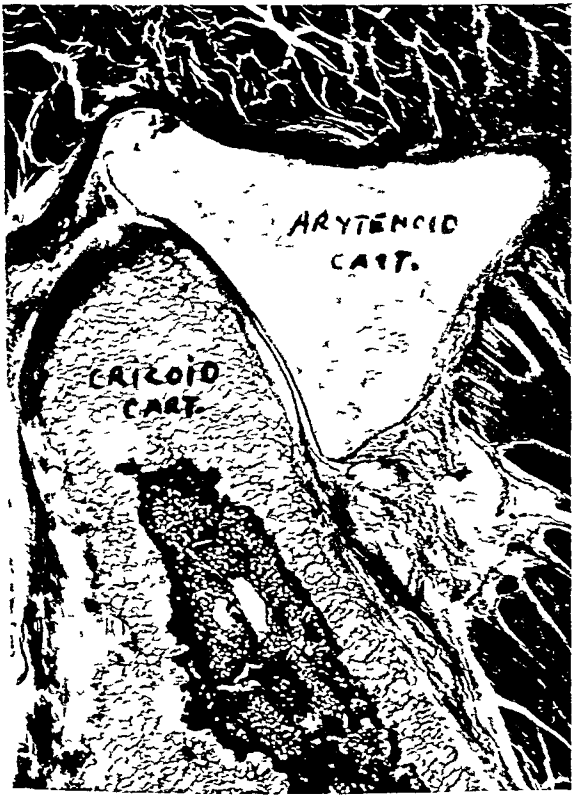

Fig 4 Microphotograph (X14) of sagittal section of larynx of a dog through crico-arytenoid joint Note marrow-like appearance within cricoid cartilage

scopy revealed both arytenoids and vocal folds to be immobile in adduction, with a very narrow glottic chink With the tube occluded there was marked inspiratory stridor but a rather good voice The larynx otherwise appeared normal in all details Neurological examination was entirely normal

Laboratory and X-ray Data was as follows Hemoglobin, 14 1 Gm, r b c, 4 2 million, w b c 9 700 with normal differential blood urea nitrogen 22 5 Blood serology negative Urinalysis normal Chest X ray negative for cardio-vascular, parenchymal, pleural or mediastinal pathology

Course in Hospital (Because Case 1 above had been seen only one month before this time the presumptive diagnosis included crico arytenoid joint ankylosis) On Dec 21 1952, direct laryngoscopy was performed under general inhalation anesthesia via tracheotomy tube with complete muscle relaxation Using the anterior commissure laryngoscope only the anterior two thirds of the cords could be slightly bowed outward The posterior one-third (occupied by the vocal processes) and both arytenoids resisted any lateral displacement whatever Further efforts to move the

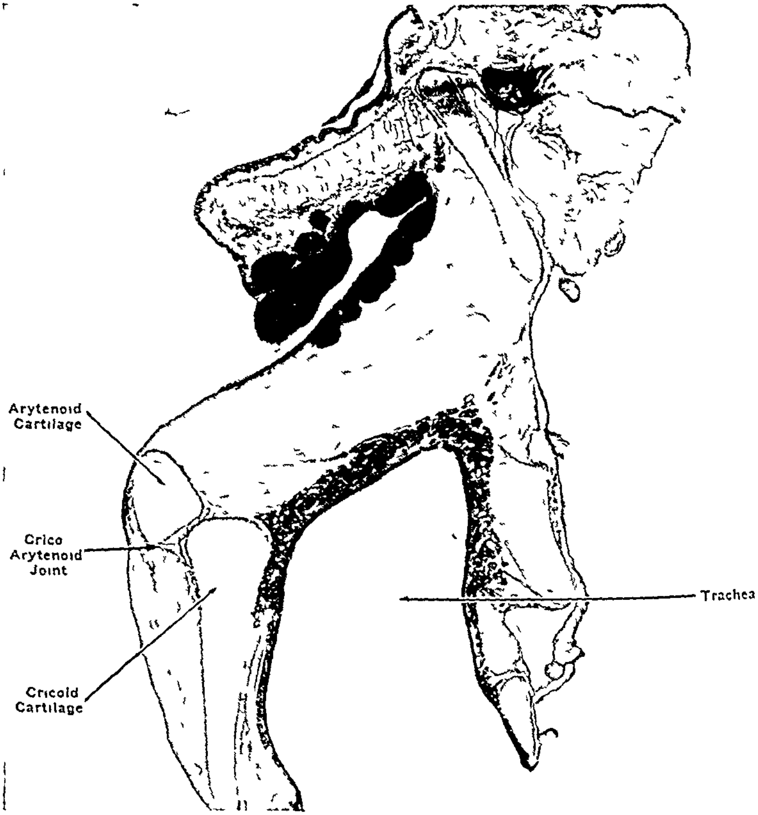

Fig 5 Microphotograph (X8) of sagittal section of larynx of a cat through crico-arytenoid joint

arytenoids and cords passively with a closed laryngeal forceps were also unsuccessful

A diagnosis of bilateral crico arytenoid joint fixation (presumably due to arthritis) was made

The patient was discharged, to return for arytenoidectomy at a later date He was most anxious to submit to this surgery in order to be rid of the tracheotomy tube

He returned on Jan 27, 1953 Careful examination for signs of other joint pathology was fruitless The Rose test a non specific serologic complement fixation test for arthritic activity was negative

On Feb 3 1953 under general anesthesia a right arytenoidectomy according to the method of Woodman[80] was performed The postoperative course was uneventful The patient was decannulated and was discharged on Feb 17 1953 The laryngeal airway was adequate, being about 5 mm at the posterior commissure

Because of the long standing tracheotomy this tract was completely epithelialized and while its sides fell together it did not heal closed, therefore, he was subsequently re-admitted, and on Sept 22 1953 the tracheal fistula was excised and the wound closed in layers This healed *per primum* and the patient was discharged for the last time on Oct 7, 1953 He has been seen at irregular intervals since then in follow-up His airway is adequate and voice satisfactory

Case 3 I L a 56-year old female was admitted as a private patient to the Long Island College Hospital on July 15 1953, on the service of Dr Benjamin Burbank an Internist Her *chief complaint* was "difficulty in breathing"

Present Illness The patient was in good health until seven years prior to admission Shortly after the onset of menopause she experienced episodes (she called them "attacks') of difficulty in breathing These were manifested by both inspiratory and expiratory distress which was accompanied by a crowing voice Similar "attacks' lasting from several minutes to several hours occurred intermittently at more frequent intervals It was also noted by the patient that over the past seven years even between attacks there was some increasing dyspnea on exertion

Seven weeks prior to admission these episodes increased in duration and severity to become almost continuous At that time she entered another hospital where she was told after several days that there was "no organic trouble" She had been seen by several physicians and had been on a number of medications the exact nature of which were unknown On occasion she had been given adrenalin for her attacks and also a nebulizer Neither of these resulted in any relief

The nature of the crowing respiration (which sounded like the voluntary crowing one can accomplish by voluntarily inspiring with cords in light adduction—as opposed to the wheeze one would get in tight adduction or laryngospasm) the type of apprehensive nervous patient with whom we were dealing the lack of response to anti asthmatic therapy and the lack of physical findings on chest examination were responsible I feel sure, for the diagnosis of no organic trouble

Review of Systems had been negative

Past History was entirely non contributory There had been no typhoid fever and no diphtheria The patient denied venereal disease There had been no trauma to the neck and no thyroid surgery There was no history of joint pains arthritis or rheumatism

Physical Examination on admission had revealed a well developed well-nourished white female in moderate respiratory distress with crowing inspiratory noises which fluctuated in intensity with no cyanosis There was no dysphagia Because of the dyspnea the patient spoke with frequent pauses between words or phrases but the voice was relatively good there being little if any hoarseness Blood pressure was 120/90 Pulse 90 to 100 Respirations 24 to 30

Laboratory Data R b c 4 63 million Hgb 14 0 gm w b c 9 250 with normal differential Sedimentation rate 11 Hematocrit 46 per cent Fasting blood sugar 128 Urea nitrogen 17 1 and urea 36 6 Total protein 7 7 with an A G ratio of 5 0 2 7 Blood chemistry Chlorides 95 calcium 4 4 phosphorus 2 3 acid phosphates 3 6 Urinalysis normal Mazzini and VDRL tests were negative Chest X ray negative for pulmonary mediastinal or cardio vascular pathology

Course in Hospital Because of the completely negative work up in the hands of a very competent internist because of the asthma like picture and not wanting to miss a possible tracheal tumor I was asked to bronchoscope the patient On July 16, 1953 preparatory to bronchoscopy the larynx was viewed with a mirror Both vocal cords were in adduction with a glottic chink of 2 mm or less There was a minute amount of motion of the arytenoids, and for the moment I felt that the patient might be holding the cords in adduction voluntarily Certainly there was enough narrowing of the glottis to explain the stridulous, crowing respiration Direct laryngoscopy was performed with the anterior commissure laryngoscope The arytenoids and cords could not be abducted A diagnosis of bilateral crico arytenoid joint fixation (presumably due to arthritis) was made Immediately following, a tracheotomy was performed to establish a more adequate airway The patient was discharged on July 21, 1953, on a course of therapy including Cortisone in an effort to establish whether the crico arytenoid joint fixation would respond to this form of treatment

She was closely followed on an ambulatory basis No increase in motion of the vocal cords developed after adequate therapeutic test, and so the patient was readmitted to the hospital on Oct 21, 1953, and a left arytenoidectomy was performed according to the method of DeBord[11] via laryngofissure Her postoperative course was uneventful She was discharged on Oct 29, 1953, still wearing the tracheotomy tube She was decannulated eight weeks later The left vocal fold had retracted laterally so that the glottis at the posterior commissure was about 4 mm wide

Subsequent Course For the next two years the patient, her husband, and her son (a medical student) were the source of considerable difficulty to me The patient herself seemed to be in good health Her voice was satisfactory, but apparently there was still occasional dyspnea on exertion, so that neither she nor her family was completely satisfied or happy, even though there were no episodes of stridor or dyspnea remotely resembling those which had occurred prior to arytenoidectomy I was quizzed on one or two occasions by the medical student son on the subject of "arthritis of the crico arytenoid joint" and derived what little satisfaction I could from learning that *he* had never heard of it

It was mutually agreed that perhaps it would be the wisest course to get an additional opinion on her status, and in September, 1955, this patient was seen in consultation by Dr Chevalier L Jackson, who was kind enough to discuss his findings with me It was his opinion that the glottic airway was not quite wide enough for complete safety It was his opinion, and I am thankful that I followed this advice, that perhaps the wisest thing would be to operate on the opposite, or right, arytenoid rather than attempt to do anything with the previously operated side Accordingly, the patient was readmitted to the hospital on Oct 24, 1955, and following preliminary tracheotomy, the right arytenoid was resected via anterior thyrotomy (laryngofissure) as described by DeBord She was discharged on Nov 6, 1955, with the tracheotomy tube in place

This time her postoperative course was somewhat complicated by the development of a polypoid mass, pedunculated, attached to the base of the epiglottis just above the anterior commissure, and covering the anterior half of the rima glottidis On Dec 12 1955, this was removed via direct laryngoscopy The second (right) arytenoidectomy bed had retracted laterally so that the glottis was now about 5 to 6 mm at the posterior commissure, and while the voice was more 'breathy" and not so strong, there was no further dyspnea or stridor The patient was decannulated on Feb 15, 1956, and since then has been getting along well

Figs 6 and 7 are histologic sections from the left and right arytenoids of Case 3 (above) They represent sections through the articular surfaces Obviously, in doing an arytenoidectomy the crico-arytenoid joint *per se* is disarticulated, so a joint cavity cannot be shown as it was in Figs 1 to 5, furthermore, the average (and even better than average) pathology laboratory is not equipped or staffed for using the celloidin technique Once a small specimen like the arytenoid is embedded in the usual paraffin block it is almost impossible to orient this block to the microtome knife so that serial sections are through the articular surface It is for this reason that histologic sections are not available on every case, furthermore, unless the process of decalcification is carefully carried out, a paraffin block will not hold the specimen in its proper relationship as well as celloidin, making it difficult to obtain a good histologic section For those which I have I am exceedingly grateful to Dr Thomas Morrione, Head of the Department of Pathology at the Long Island College Hospital

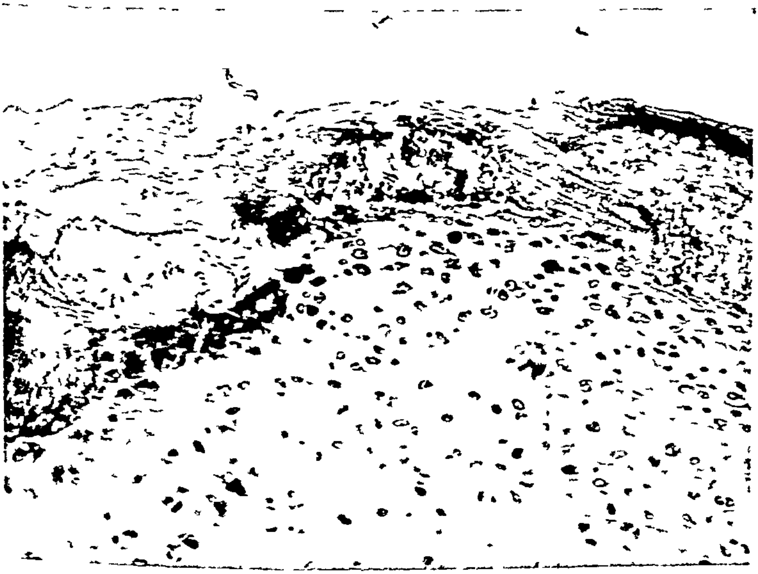

Fig 6 Microphotograph (X125) of left arytenoid from Case 3 (This was the first arytenoid operated upon in this case) The articular surface is irregular in contour and shows tearing out of the tissue as a result of the microtome knife dragging through what was probably calcified surface Many of the cartilage cells beneath this area are calcified To the right of it lacunae and canaliculi are forming as bone develops To the left may be seen a portion of the synovial joint space of the crico-arytenoid articulation It is lined by endothelial cells On the articular surface the cartilage cells show fragmentation and fibrillary changes in the few localized areas These changes are compatible with those seen in degenerative arthritic changes Diagnosis Arytenoid cartilage showing changes compatible with arthritis

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Laboratory and X-ray Data Complete blood count was within normal limits, serological test for syphilis was negative, urinalysis was within normal limits Blood uric acid was 3 7 The Rose test was negative Chest X-ray was reported as negative for cardiovascular, pulmonary, pleural or mediastinal pathology

Course in Hospital On Feb 24, 1955 in order to test for passive mobility of the cords, a preliminary tracheotomy was performed followed by direct laryngoscopy under general anesthesia Pressure with the anterior commissure laryngoscope and with a closed laryngeal forceps revealed that both cords were fixed in the mid-line with bowing possible in the anterior two thirds but no motion of the arytenoid cartilages The glottic chink at the posterior commissure was approximately 2 mm in width On March 9 1955 under general anesthesia a left arytenoidectomy was performed via laryngofissure approach according to the method of DeBord By April 1 1955 mirror laryngoscopy revealed that most of the edema had subsided from the larynx except for the anterior third of the left cord The left cord at the posterior commissure was retracted approximately 4 mm at this time Incidentally the patient was well enough on April 15 1955 to have a circumcision performed On April 26 1955 he was sent on a 30 day leave of absence following which indirect laryngoscopy revealed the airway to be quite adequate with a posterior glottis of approximately 5 mm The voice was breathy but satisfactory The tracheotomy tube was removed and the patient was discharged on May 27 1955

Subsequent History The patient was re admitted on Dec 12 1955, because of the development of a "tight scar' in the area of the previous tracheotomy This was revised and he was discharged on Jan 5 1956

The patient was re-admitted on Nov 13, 1957 because of increasing hoarseness and slight dyspnea of approximately ten days' duration Indirect laryngoscopy revealed a considerable amount of diffuse polypoid hypertrophy of the left vocal fold so that the anterior two thirds of the glottic chink was completely obstructed and a relatively small aperture was present in the region of the posterior commissure The posterior end of the left or previously operated vocal cord still appeared to be approximately 5 mm away from the right arytenoid Because of the dyspnea and poor cooperation on the part of the patient under local anesthesia a preliminary tracheotomy was performed through the old scar and via direct laryngoscopy under general anesthesia the left vocal cord was stripped On Nov 30 1957 patient was decannulated The voice and airway were satisfactory, and the patient was discharged on Dec 9 1957 He has had no difficulty since then

Case 5 R D a 51 year old white female was referred to me at the office on July 23 1956 by Dr Charles R Weeth Director Department of Otolaryngology Long Island College Hospital In April 1956 the patient developed dyspnea and hoarseness or dysphonia which increased over a period of several days finally terminating in an episode of loss of consciousness with admission to a local hospital on an emergency basis There she responded to rest following initial oxygen therapy and was discharged after 24 hours somewhat improved but still feeling that there was remaining shortness of breath Incidentally she gave a history of asthma' for two years prior to this The day after her discharge from this hospital she developed acute respiratory distress with cyanosis and unconsciousness She was taken to another hospital where an emergency tracheotomy was performed She remained in the hospital for a period of

In all of the reference material cited in this thesis, the article by Pearson[15] contains the only histologic section of a crico-arytenoid joint His patient died of an intercurrent broncho-pulmonary infection and the entire larynx was obtained at autopsy

Case 4 J H, a 28 year old colored male was admitted to the Brooklyn Veterans Administration Hospital on Feb 9 1955, for evaluation and treatment because of "hoarseness and difficulty in breathing"

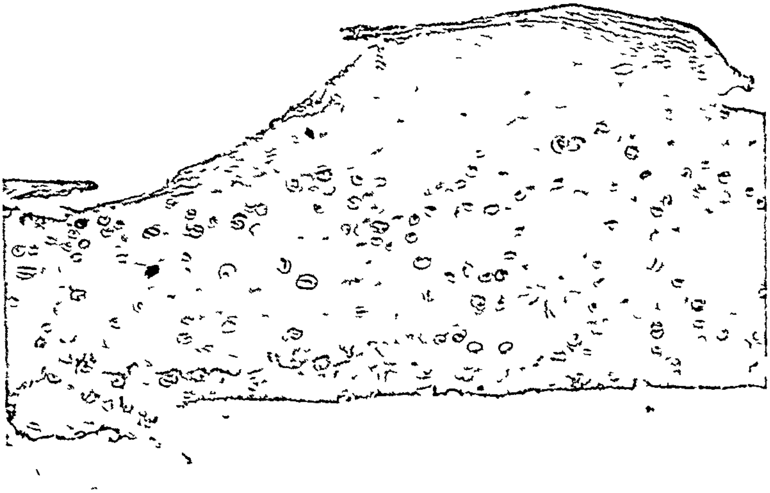

Fig 7 Microphotograph (X125) of the right arytenoid from Case 3 (This was the second arytenoid operated upon in this case) This area shows an overgrowth of cartilage and fibrous tissue on one portion of the articular surface of the cartilage Diagnosis Arytenoid cartilage showing changes compatible with arthritis

Present Illness The patient stated that his present difficulty began in 1951, following an upper respiratory infection when he developed hoarseness and dyspnea which progressed in severity He was in the Armed Forces at the time and had been sent to Alaska but was returned to the United States and hospitalized at Walter Reed Army Hospital where a diagnosis of "vocal cord paralysis" was made He was subsequently discharged from the service on June 9, 1952 with a 10 per cent disability compensation for vocal cord paralysis Since that time he has noted slowly progressive increasing dyspnea and hoarseness

Past History was negative for diphtheria and typhoid fever He had always been in good health except for his above noted present illness There was no history of neck trauma no thyroid surgery and no other neurological symptoms He denied ever having had venereal disease There was no history of arthritis rheumatism or joint pains

Physical Examination revealed a well developed well nourished colored male who was slightly dyspneic at rest, this dyspnea increasing on exertion Blood pressure was 125/75, the remainder of his general physical examination was entirely negative Indirect laryngoscopy revealed a bilateral mid line position of the vocal cords

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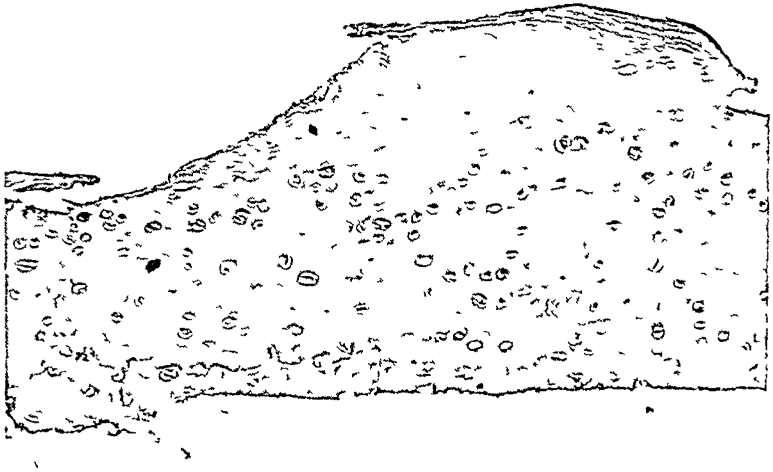

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Physical Examination revealed a well developed well nourished colored arthritis involving the elbows, wrists knees and small joints of the hands characterized by hypertrophic periarthritic changes, cartilaginous necrosis, articular surface erosions and subarticular cystic degenerative changes"

The patient was treated medically principally with salicylates and ferrous gluconate, with codeine for severe pain

She was readmitted to the Long Island College Hospital on Nov 24, 1956 for steroid therapy prior to arytenoidectomy On Dec 3, 1956 a right arytenoidectomy was performed via thyrotomy her postoperative course was uneventful and she was discharged from the hospital on Dec 12, 1956

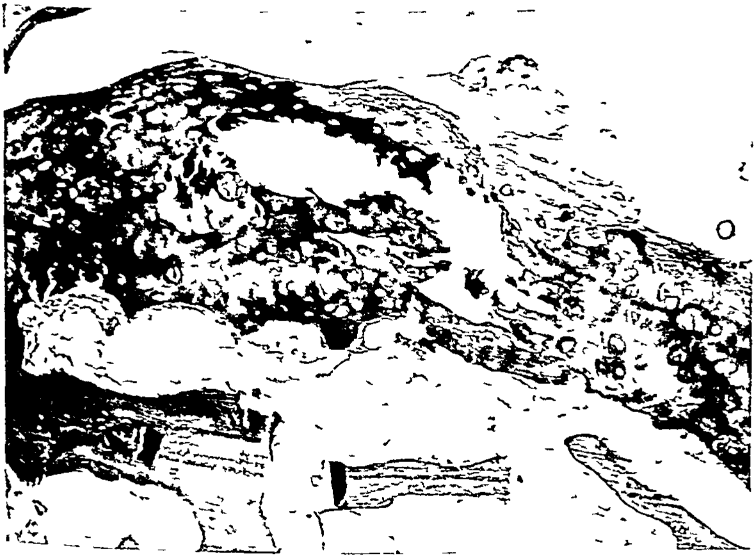

Fig 8 Microphotograph (X125) from Case 5 of a section of arytenoid cartilage showing an articular surface covered with perichondrium that contains a very irregular contour in relation to the articular surface Extensive fibrosis is present which dips down into the scalloped surface of the cartilage Approximately 0 5 mm below surface the cartilage is extensively replaced by bone containing wide expanses of fatty marrow The cartilage cells show some disturbance in their arrangement The surface shows increase of fibrous covering Diagnosis Osteoarthritis of arytenoid joint surface

She was then followed ambulatory in my office and on Jan 29 1957 the postoperative edema of the larynx had subsided and the right vocal cord had retracted laterally so that the glottic chink at the posterior commissure was approximately 5 mm across The patient could tolerate complete closure of the tracheotomy tube for about one week prior to this date so on that day she was decannulated Because of the fact that the tracheotomy tube had been in place from the latter part of July 1956 to the latter part of January, 1957 a period of six months a small tracheal fistula persisted and the patient was readmitted on June 20 1957 for plastic closure of the tracheal fistula She was discharged on June 23 1957 approximately ten days The tracheotomy was performed by one of the thoracic surgeons on the staff I do not know of any otolaryngologic consultation while she was in this hospital Her physician had difficulty in decannulating her and she was discharged with the tracheotomy tube still in place Following this, she was seen by the referring otolaryngologist who admitted the patient to the Long Island College Hospital on June 24 1956, for direct laryngoscopy and removal of a polypoid pedunculated mass occupying the anterior half of a narrow glottic chink Her laryngologist noted what he described as some abductor weakness, or incomplete abduction of the vocal cords at this time, but felt that her glottic chink was adequate and followed her on an ambulatory basis after discharging her on the following day During the subsequent month several attempts were made to decannulate the patient, and she apparently successfully tolerated complete closure of her tracheotomy tube for a number of days and was decannulated On several occasions during this time, her laryngologist noted the lack of abduction on the part of both vocal cords, but with the partially obstructive polyp out of the way both he and the patient felt that she could get along, particularly in view of the fact that the tracheotomy tube had been corked for a number of days About July 21, 1956, however, during a visit to his office, it became obvious that the glottic chink was not adequate, and because of his knowledge of my interest in cases of this nature, and suspecting a crico arytenoid joint arthritis, he kindly referred the patient to me I saw the patient in my office on that day, and indirect laryngoscopy revealed a glottic chink of 2 to 3 mm at the posterior commissure with mild dyspnea, a fairly good voice and no cyanosis I felt, however, that this was a dangerously small laryngeal airway and recommended that the patient have a tracheotomy

She was admitted on my service on July 25, 1956, and a preliminary tracheotomy was performed with the insertion of a No 6 tube Following this, direct laryngoscopy under general anesthesia was done to test for mobility of the vocal cords and crico arytenoid joints The anterior two thirds of the cord could be bowed but both arytenoid cartilages were fixed, so that abduction was not possible Arytenoidectomy was recommended, but the patient chose to delay this procedure temporarily, and she was discharged on July 27 1956 At this time she was referred to an Internist for medical consultation and thorough work-up, and for control of an obviously active rheumatoid polyarthritis She was seen by him on Aug 21, 1956, for the first time, and thorough medical work up was begun She was seen by him again on Sept 10, 1956, and Oct 30, 1956, prior to readmission for definitive surgery on the larynx His history indicated that the patient had had arthritis for 12 to 13 years involving multiple joints She had been on Cortisone and several other drugs, prescribed by preceding physicians taking care of her In August of 1956, her chest X-ray was negative His impression was that the primary problem was an active rheumatoid arthritis, and that gout had to be ruled out

Laboratory findings were as follows At the time of admission to the hospital for initial laryngoscopy and polypectomy and subsequently, her red blood cells ranged from 4 5 to 4 9 million, her hemoglobin between 11 and 13 gms Her white count on several occasions ranged from 7,800 to 10,850 with 67 per cent polys in the former instance and 17 per cent polys in the latter instance Serology was negative Sedimentation rate on Aug 23, 1956, was 57, at which time there were 9,150 white cells with 76 per cent polys Her fasting blood sugar ranged between 100 and 124 urea nitrogen was 13 5 urea 28 6 Her urine was repeatedly normal A C reactive protein was reported slightly positive on Aug 23 1956 On the same date, uric acid was 3 2 total protein 7 4 serum albumen 4 7 serum globulin 2 7 X ray studies on Aug 23, 1956, revealed "generalized

Physical Examination revealed a well developed, well nourished Negro male with moderate stridor, both on inspiration and expiration Pulse was 64 Blood pressure 120/85 The remainder of the physical examination was entirely negative except for mirror laryngoscopy which revealed a midline position of both vocal cords with no abduction

Laboratory and X-ray Data A white count on admission was 11 100, hemoglobin was 13 2 gm Urinalysis was normal The cardiolipin microflocculation test was positive in 1 8 titer X-ray revealed no evidence of cardio vascular, pulmonary, pleural or mediastinal pathology

Course in Hospital On March 22, 1957, the patient had a preliminary tracheotomy On March 26, 1957, direct laryngoscopy was performed under general anesthesia administered via the tracheotomy tube The anterior-commissure laryngoscope was introduced in order to test for mobility of the crico arytenoid joints Insertion of the tip of the scope in the anterior commissure resulted in a bowing of the anterior two thirds of the cords with no lateral motion at the crico arytenoid joints These remained in the mid line position Following the preliminary test for passive mobility of the vocal cords a left arytenoidectomy was performed via a laryngofissure approach according to the method of DeBord By April 17, 1957, the postoperative laryngeal edema had subsided sufficiently so that the tracheotomy tube was removed The glottis at the posterior commissure at this time was approximately 5 mm in width, which was adequate and while the voice was somewhat "breathy" it was perfectly serviceable The patient was discharged on May 2 1957

REVIEW OF LITERATURE AND COMMENTS

As has been noted, at the time I saw my first case of ankylosis of the crico-arytenoid joint in 1952, a hasty check of the more recent American literature revealed only the case reported by Myerson[32] in 1943 It is interesting to note that the author seems to relate the development of a progressive bilateral crico-arytenoid ankylosis to an episode of peritonsillar abscess which preceded it by a period of several months There was no similar antecedent history in any of my cases

In December, 1955, Montgomery, Perone, and Schall[29] reported on four of six cases which they had seen Their article directed my attention to American otolaryngological textbooks, in which they state, "arthritis of the crico-arytenoid joint is described "

For the most part, these textbook references are not extensive, yet they contain a great deal of information For example, Boies[4] in the chapter on Hoarseness has a section titled "Fixation of Range of Movement of the Crico-arytenoid Joint," in which he states that this joint "may become partially or wholly fixed in its normal range of movement by inflam-

This patient has been followed periodically regularly She has an adequate airway and a serviceable voice which she uses to excess She is being carried on small doses of Cortisone for her polyarthritis and is thoroughly rehabilitated

The pathological report reads as follows "Microscopic description Section of the decalcified specimen shows that the cancellous bone is covered by cartilage which in turn is covered by layers of fibrous tissue The cartilage cells show some disturbance in their arrangement The surface shows an increase of fibrous covering No fibrinoid changes are noted on the surface Diagnosis Osteoarthritis of the crico arytenoid joint" (see Figs 8, 9)

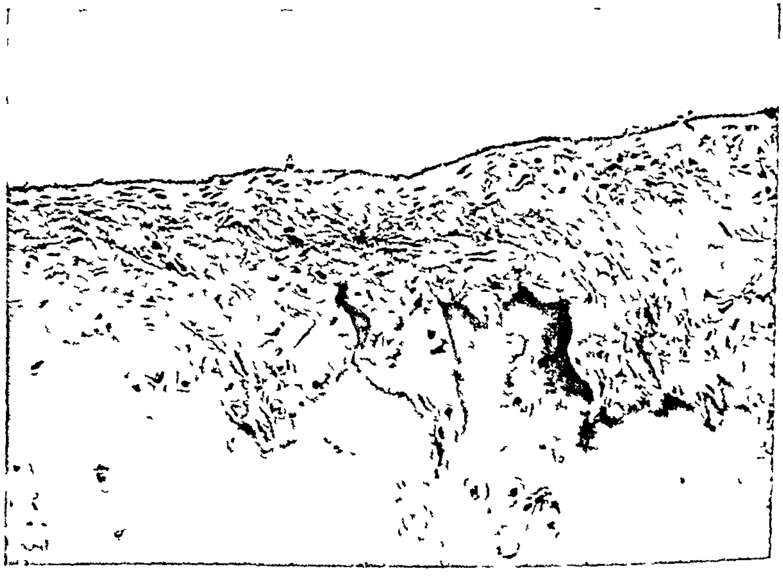

Fig 9 Microphotograph (X90) of an area from the hip joint of a 52-year-old male Diagnosis osteo-arthritis Note similarity of alteration in the articular cartilage compared with Figs 6 7 8 including fibrous dysplasia on surface aspect with scalloping of cartilage

Case 6 W E, a 25 year old colored male was admitted to the Brooklyn Veterans Administration Hospital on March 7 1957 complaining of hoarseness of about one year s duration and increasing shortness of breath of about three or four weeks' duration He had recently seen a local physician who had advised surgery

Review of Systems was non contributory

Past History He stated that he had had an occasional episode of "arthritis" in the past, which consisted principally of mild joint pains in the large joints such as the knees wrists and elbows however there was no clinical evidence of arthritis at the time of his admission to the hospital in the nature of fever redness swelling or limitation of motion There was no history to suggest diphtheria or typhoid fever He denied ever having had any venereal disease There was no history of trauma to the neck There had been no thyroid or anterior neck surgery

Continuing with American textbook references, we come to Chevalier Jackson[21] in which, in the chapter on Trauma of the Larynx the author, discussing ankylosis of the crico-arytenoid and crico-thyroid joints, says, "Traumatic ankylosis is more frequent than laryngeal literature indicates, but as compared to the incidence of ankylosis of these joints as a sequela of arthritic disease it is rare." This is a most interesting, and, at first blush, puzzling observation, however, it is nonetheless factual. This is because, while there is not a great deal in the recent literature on arthritis of the crico-joint, there is a fair amount in the literature of 30 to 65 years ago, while there is surprisingly little on traumatic ankylosis.

The same author, under Diagnosis, states that, "In crico-arytenoid ankylosis the absence of arytenoid movement is instantly recognizable in the mirror, but to make a diagnosis of ankylosis, recurrent paralysis must be excluded. This can be done readily by the Jackson 'passive mobility test.' In this test the closed laryngeal forceps are used through the laryngoscope to test passive mobility. The rigid fixity of the anklosed arytenoid is strikingly different from its free passive mobility in cases of cordal paralysis."

One does not take issue with the foregoing. As a *confirmatory* test it puts the final seal of correctness on what should, by the time one gets to direct laryngoscopy in a suspected case, be a strong presumptive working diagnosis. The important point is that, as noted previously, one should rule out with a detailed history, those diseases which might conceivably cause crico-arytenoid fixation—such as diphtheria and typhoid fever (even though today these are rarely seen), rule out lues on history, examination and serology, rule out trauma, again with adequate history and physical examination, rule out thyroid or other low anterior neck surgery; rule out chest pathology which might involve the recurrent nerves (and while this is of great importance in unilateral cord immobility, particularly left-sided, it is almost inconceivable that bilateral recurrent paralysis without thyroid or other neck surgery, which should be obvious, could occur) again with history, physical examination and in addition matory processes involving it from adjacent infection, trauma, or in an arthritic process such as may occur in any other joint If the involvement is unilateral there may be relatively little interference with phonation and thus only slight, if any, hoarseness

"The diagnosis of fixation is determined by testing the passive mobility of the arytenoid This is done by palpating it with a blunt instrument through the direct laryngoscope In cases of an obstructive bilateral fixation the joints may be mobilized through surgery"

Certainly there is a great deal of information in the foregoing, and for those willing to explore basic texts it is available

Morrison,[30] on the other hand, has this to say under Affections of the Crico-arytenoid Joint "Etiology the arthritis is usually a destructive one which follows invasion of the joint by local infection and ulceration in tuberculosis and syphilis, contact ulcer, abscess of the arytenoid, perichondritis of the arytenoid or cricoid cartilages and trauma during direct laryngoscopy, bronchoscopy or forceps removal of tissue about the joint It may occasionally be a rheumatic, non-suppurative process Fixation follows suppuration in the joint because of scar formation and ankylosis"

Except for his reference to a rheumatic, non-suppurative process, neither my cases, nor those reported by Montgomery, et al ,[29], Copeman,[9] Pearson,[35] Baker and Bywaters[2] and Reaves[37] indicate that any of the other possible etiologic factors mentioned were involved, however, there is considerable material to support Morrison in the earlier, foreign and American literature[1, 4, 13, 15, 18, 20, 23, 33, 39] referring to the acute and chronic processes as being of etiologic significance

Morrison[30] further states that "fixation of the cord is not amenable to any known form of treatment once the condition has become established" I presume that he refers here to treatment which will make the arytenoid move again If this is so then I agree Since he does not refer to bilateral midline fixation one cannot be at all critical, however, this reference might bear some clarification in future editions

Throat Service at a particular institution has its own facilities for the preparation of histologic sections much of the material with which we are vitally concerned, cannot properly be processed This may not be too extensive a problem with regard to tissues sent to Pathology from operating rooms where in most cases, the tissue is soft; but how often do we get unsatisfactory reports on hard tissues such as bone and cartilage (the latter in many cases having undergone ossification). Much more important, how often are we frustrated in attempting to get sections from autopsy material of temporal bones, sinus walls, and larynges? This, after all is the very reason why the American Academy of Ophthalmology and Otolaryngology has seen fit to set up central laboratories for the processing and reading of histologic sections of temporal bones

There is good and ample reason for this The average hospital pathology department is not set up to process this kind of material They dislike the tedium involved in decalcification, and the additional laboratory technical assistance required Their material is embedded in paraffin because it is quicker and more simple They are not equipped to embed tissues in celloidin Even where the surgeon is interested enough to follow the tissue down to the pathology laboratory he finds it difficult to orient an ossicle, for example or a cupola, or, as in this instance, an arytenoid cartilage once it is embedded in paraffin, so that sections will arrive on slides in a manner best suited for useful histologic reading Paraffin is practically opaque Celloidin is relatively translucent—almost transparent, furthermore, with ossified material, paraffin will often not hold tissues in their proper relationship against the cut of the microtome knife Celloidin usually will

These are some of the problems which resulted in the fact that there is not a microphotograph for each of the cases reported herein For those which I have I am exceedingly grateful, for those which are absent, my apologies

Montgomery, Perone and Schall[illegible] in 1955, remark that there is nothing in the American literature on crico-arytenoid joint arthritis "in the past thirty years," yet, included in their bibliography is the report of Myerson[illegible] in 1943 I mention

X-ray examination, rule out bilateral vagus nerve involvement (and so the recurrents) within the brain, by physical examination alone, and easily—for it is impossible to have a bilateral vagus nerve paralysis without involvement of at least one and probably not without all three of the following Glossopharyngeal, spinal accessory and hypoglossal

Having done all this in a case where there is bilateral mid-line position of the cords, it is my opinion that a strong presumptive diagnosis of *fixation* of the crico-arytenoid joint is justified, and on the basis of the experience with my six cases, this is true whether or not there is or has been, associated arthritic changes in any of the other joints of the body It should be noted that in only two of these cases was there any history or findings to suggest polyarthritis

This is the kind of history, physical examination and diagnostic reasoning which, I feel, make a good physician—the first requisite in making a good otolaryngologist, and one of the points which I wanted to make in this paper

It goes without saying, I hasten to add, that one must still *confirm* the diagnosis, and this can be done simply by testing for passive mobility of the cords as described by the senior Jackson

It would seem appropriate here to follow with the problem of further confirmation—by histologic section of the arytenoid removed at operation We are all aware of the great importance of the work of hospital Tissue Committees We are aware that the Combined Committee on Accreditation of Hospitals insists that these Tissue Committees oversee the material which comes out of operating rooms and passes through departments of pathology, so that they may check the agreement percentage between preoperative, postoperative and microscopic diagnoses We have the anomalous situation, in connection with the pathological material presented in this paper, of my having had a rather difficult job in attempting to get the departments of pathology of the hospitals concerned, to provide me with histologic diagnoses and proper sections

This is not a new problem for us as otolaryngologists, for we know that, in most instances, unless the Ear, Nose and losis is, however, a far rarer occurrence and one which, if the cords are fixed in the medial line, fraught with grave consequences to the life of the patient ”

Newcomb[24] in 1893, in a journal no longer in existence, reports on “Rheumatism of the Crico-arytenoid Joint ”

It was Casselberry,[7] however, as far back as 1893, in the Transactions of the American Laryngological Association, who wrote a most remarkable dissertation, scientific and somewhat philosophical, on the subject of “Arthritis Deformans of the Larynx ” He concerns himself with the “propriety” of introducing this title (*i e*, Arthritis Deformans) into laryngeal nomenclature, and leaves its final disposition up to pathologists, as it may or may not relate to Arthritis Deformans in general, the disease also known as Rheumatoid Arthritis He states that, “From careful studies of the morbid anatomy of arthritis deformans R Volkmann (cited by Weber) recognizes the rapid proliferation of the articular cartilaginous elements, particularly on the free surface of the cartilage as the essential factor of the disease, together with subsequent absorption of the cartilages” (see Figs 6-9) He continues, “Garrod failed to discover any pathognomonic change in the blood, and Weber states that it is a fact that uric acid has not been found in the blood and that analysis of the urine has failed to show unusual increase in uric acid or urates ” This has been true in the cases reported here as evidenced by the laboratory findings included in the case reports

While the American literature has not contained much on this subject, the foreign literature has contained more, however, many of these references, as previously noted, deal with acute involvement of the crico-arytenoid joint, and most of them refer to unilateral involvement They do not concern themselves so much with bilateral mid-line fixation of arytenoids and cords Errecart,[13] for example, reports a case of gonococcal involvement of the crico-arytenoid joint Haardt[15] deals with the clinical and pathological anatomy of perichondritis of the cricoid cartilage Herzog[17] demonstrated a case of a 41-year-old male who had difficulty in breathing for ten years Examination with a sound revealed bilateral crico-this, not as a criticism of their paper, for one can easily understand how an oversight of this kind might occur Actually, the paper of Myerson[32] is the only one which has come to my attention in the American literature on laryngology in the 30 years from 1926 to 1955, however, not on the exact subject, but closely allied is an interesting report by Babbitt[1] in 1922, written in the formal narrative style of that day, in which he reports the "Loss of Both Arytenoid Cartilages" Somewhere in the neighborhood of three weeks after major abdominal surgery and the postoperative use of a feeding tube, and, " some eighteen days after my first examination, the patient coughed out what appeared to be the left arytenoid cartilage, and in two or three days the right one followed X-ray, fluoroscope and laboratory examinations confirmed the diagnosis This was further proved by conference with a professor of anatomy and one of our leading laryngologists One specimen I present for examination, the other was sectioned at the laboratory Two or three weeks following this, the patient commenced to recover voice, and after some six weeks was able to produce a fair tone without, however, much variation in pitch"

This case is cited for two reasons first, because I suppose that if the arytenoid can undergo a morbid process which results in its sequestration there would seem little doubt that it may also be the seat of an arthritis resulting in ankylosis, second, because in Case 3 above, while the patient did not cough up her arytenoids, I removed both of them—and she has a serviceable voice Actually this is because of the usurpative action of the ventricular folds, a dysphonia plicae ventricularis

Another American reference is Harris[16] in 1919, in which he reports a case of ankylosis (spelled anchylosis at the time) of the crico-arytenoid joint on both sides requiring tracheotomy He reports that anchylosis of the crico-arytenoid joint is a more common affection than is generally supposed, and that in its acute form it is undoubtedly often overlooked, while in its chronic form, when only one side of the larynx is involved, "without question" is often mistaken for recurrent nerve paralysis He goes on, "Bilateral crico-arytenoid anchyafter perichondritis, but having been accidentally omitted in its proper place I have thought it better to insert it here, affections of the joint being so likely to be mistaken for muscular paralysis."

The section continues:

"Notwithstanding the exposed position of the crico-arytenoid articulation fixature of the joint must be rare, for immobility of the vocal cords is not a very common condition, and when it does exist it is often due either to nervo-muscular affections or to general tumefaction of the soft parts which mechanically prevent the movements of the cords. That it does occasionally occur there is little doubt. This subject has not been hitherto treated with any detail, although the condition has been incidentally referred to by Turck,[40] Sidlo,[45] Ziemssen,[52] Mandl,[27] Schroetter,[41] Koch,[22] Burow, Jun[5] and Semon.[43] Anchylosis of the crico-arytenoid joint may arise from perichondritis or chondritis, either of which may occur primarily or result from extension of disease from the superadjacent soft parts. It is probable also that it may be due to primary synovitis either rheumatic, gouty or simply catarrhal, and in some cases it most likely arises from mere disuse brought about either through the muscles having been previously paralyzed or through changes in the contiguous parts preventing the movement of the joint for a long period and thus giving rise to permanent anchylosis; or the fixature may be due to traumatic injuries such as wounds, contusions or dislocations. Perichondritis, generally due to typhoid fever or syphilis, is undoubtedly the most common cause of the affection, for according to Dr. Semon, out of ten cases on record, in five instances the disease was due to inflammation of the perichondrium covering the cricoid or arytenoid cartilages. The symptoms vary according as the disease is unilateral or bilateral, according to the degree of mobility of the joint, and according to the position in which the arytenoid is fixed on the cricoid cartilage. Thus, if the arytenoid be fixed on the outer part of the cartilage we have the vocal cord permanently drawn aside and permanent dysphonia, whilst if the arytenoid cartilage is fixed near the center of the cartilage, the vocal cord arytenoid joint fixation The glottis at the posterior commissure was 2 mm wide

Hiraoka[18] reports a case of acute rheumatism of this joint Horbst[19] deals with the pathologic histology of arthritis of the crico-arytenoid joint Hutter[20] speaks of the "localization" of acute arthritis in the larynx Levinstein[21] refers to acute rheumatoid arthritis of the larynx Litten[24] states that gouty depositions in the larynx are among the greatest rarities, and that in all of the gout literature there is only one reference by Virchow to a gouty tophus in the larynx

Mygind[33] classifies affections of the crico-arytenoid joint in respect to etiology as follows *1* primary crico-arytenoid joint arthritis resulting from acute infections, *2* primary crico-arytenoid joint arthritis resulting from chronic infections or toxic diseases, and *3* various forms of rheumatic disease of the crico-arytenoid joint or in the immediate neighborhood of the crico-arytenoid joint

Ritter[30] reports a case of acute rheumatoid arthritis with beginning symptoms referred to the larynx

G H Mackenzie[25] in 1894 stated that, "It is only within a comparatively recent period that attention has been directed to the manifestations of rheumatism in and about the larynx Probably the most conclusive proof of the accuracy of this assertion is that no mention of this condition is made by Morell Mackenzie in his great work on diseases of the throat and nose, published in 1880 and 1884"

The above reference fascinated me, for in Morell Mackenzie's[26] text on "Diseases of the Pharynx, Larynx and Trachea," published in 1880, the author has the following to say, and considering the fact that it was written almost 80 years ago one cannot help but marvel at the clinical acumen of our forebears I quote from it almost *in toto* because there has been very little said in the literature after this which he does not say here

The section of this book titled "Anchylosis of the Arytenoid Articulations" contains the following footnote

"This article would have been more appropriately inserted gressive process may well occur, to result in increasing impairment of mobility of the crico-arytenoid joint. How, otherwise, can one explain the relatively long and intermittent histories in every case of mine, prior to the final episode which resulted in truly disabling dyspnea? In many instances I feel that earlier acute or subacute exacerbations of joint pathology were probably responsible for the diagnosis of "asthma." In these stages anti-asthmatic therapy was to no avail. Why would it be? In these stages, while there is still *some* motion at the joint on mirror laryngoscopy, even the best of us are likely to mistake the incomplete abduction for the kind one so often sees in a patient who is anxious and not fully cooperative; furthermore, is this not the usual natural history of generalized rheumatoid arthritis—with its spontaneous exacerbations and remissions, and an intermittently progressive deformity and increasing fixation of whatever joint may be involved? While one might expect to see some remission on steroid therapy in an acute exacerbation, is there any reason to suppose that this kind of therapy will result in increased motion of a joint which has already become completely ankylosed? Cortisone had no effect in any of the cases on which I have reported.

Copeman[9] continues: "The differential diagnosis in these and similar cases would appear to lie between rheumatoid arthritis involving the crico-arytenoid joints and paralysis of the recurrent laryngeal nerves in rheumatoid subjects due to some unknown local or general cause of which no evidence can be found. The distinction, which can finally be made only by a *laryngologist of experience* (italics are mine), remains difficult and perhaps uncertain."

I find it hard to agree that bilateral abductor paralysis cannot be easily excluded in this differential diagnosis. It cannot occur centrally without other neurological symptoms and signs; it cannot occur peripherally except following thyroid surgery, or where there is intrathoracic (left-sided) disease *and* low cervical (right-sided) disease of a nature which would involve the recurrent nerves. Nor can I disagree when he states that the final distinction can be made only by a laryngologist of experience.

is permanently fixed near the medianline, and there is persistent dyspnea

"The diagnosis of the condition is attended with some difficulty, and paralysis of either the adductors or the abductors may simulate anchylosis The affection may, however, be inferred to exist when immobility of one or possibly of both vocal cords is accompanied by some irregularity in the form of the cartilages or the upper part of the cricoid cartilage It should also be especially looked for in the case of patients who are convalescent from typhoid fever and have some alteration in voice or difficulty in breathing I am not aware that any treatment would be likely to give very satisfactory results, but if the arytenoid cartilages are fixed in a central position forcible dilatation should be affected according to the mechanical methods laid down in the last article, after tracheotomy has been performed, and this treatment should, if possible, be employed prophylactically in cases of perichondritis after typhoid fever and syphilis, in which considerable destruction of the joint has taken place, and subsequent anchylosis is to be feared"

One need only remark that at that time typhoid fever and untreated syphilis were much more common than now, and, secondly, that the operation for arytenoidectomy had not been described at that time

Copeman[9] in a much more recent article remarks that, "There appears to be no reason why rheumatoid disease may not affect the crico-arytenoid joints in similar fashion to other larger diarthrodial joints of the body If this is true, we should expect to observe cases which exhibit phases of recurrent acute or subacute inflammatory reaction either confined to these joints or, more probably, as part of a generalized arthritic process In the later chronic stages of the disease, and usually as the sequel to recurring episodes of this nature, more permanent impairment of movement or even ankylosis of the crico-arytenoid joints might occur"

This is very well expressed, and even though in only two of the cases described in my paper was there any evidence of polyarthritis, I feel that the same sort of intermittently pro-occur in the crico-arytenoid joints alone, and whether the case reported by Shambrom and Feher[44] with sterno-costal and crico-arytenoid joint involvement, is not a frequently over-looked variation of the multi-faceted, generalized or localized morbid process called rheumatoid arthritis

SUMMARY AND CONCLUSIONS

The anatomy, gross and histologic, of the crico-arytenoid articulation has been reviewed

Evidence that this is, and should be thought of as, a true diarthrodial joint is presented

Six cases are reported in which there was bilateral ankylosis of the crico-arytenoid joint with fixation of the vocal cords in the mid-line and resultant dyspnea requiring tracheotomy

This ankylosis was the result of rheumatoid arthritis

In four of these cases there was no evidence that any joints other than the two crico-arytenoid joints were involved

Important points in the differential diagnosis have been presented

The condition is amenable to surgical correction This is to say that the airway may be made adequate, and a serviceable voice may be retained. Medical management is not adequate

The treatment consists of the required preliminary tracheotomy, followed by any one of the various operations described for arytenoidectomy or arytenoidopexy

The literature appertaining hereto has been reviewed and comments made thereon

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It should be noted, that while the article by Snell[46] does not deal with pathology involving these joints, it is included here because it is an extremely good treatise on the function of the crico-arytenoid joints in the movements of the vocal cords Since it appears in a journal which is not likely to come before the otolaryngologist I take the liberty of calling attention to it here

It remains now only to call attention to a recent article by Shambrom and Feher[44] in which these authors report a case of Tietze's syndrome with involvement of the crico-arytenoid joint They are not aware of this association having been reported before Tietze's syndrome is a benign, self-limiting disease characterized by tender, non-suppurative swelling over the upper costal cartilages Usually one of the second costal cartilages is involved, multiple involvement of costal cartilages is uncommon Pain usually persists for a few days to a few weeks while swelling may continue for months or even years According to Motulsky and Rohn[31] its cause is not known, non-tuberculous respiratory disease or rheumatic conditions frequently precede or accompany the syndrome On an anatomic basis, they suggest that small tears or rheumatoid involvement of the inconstant inter-articular sternocostal ligament may be a factor in the etiology

Shambrom and Feher[44] believe that involvement of the crico-arytenoid joint in their patient with Tietze's syndrome suggests that the condition can be more disseminated in the body than was previously thought They state that, as more cases are described it is probable that more areas of the body (*i e*, more joints) will be found to be involved

Attention is called to this syndrome for several reasons first, if as noted, it may involve the crico-arytenoid joint, then as laryngologists we should be familiar with it, second, the clinical syndrome described is not remarkably different from rheumatoid arthritis elsewhere in the body, third, while perhaps not a diarthrodial articulation, the sternocostal junction is an articulation

I wonder, therefore, whether this syndrome is not really another manifestation of rheumatoid arthritis, just as may

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COURSE IN LARYNGOLOGY AND BRONCHOESOPHAGOLOGY

The course in laryngology and bronchoesophagology, under the chairmanship of Paul H Holinger, M D, is scheduled November 9-21, 1959

Interested physicians should write direct to the Department of Otolaryngology, 1853 West Polk Street, Chicago 12, Ill

PURE-TONE THRESHOLD PATTERNS OBSERVED IN FUNCTIONAL HEARING LOSS

JOSEPH B CHAIKLIN, Ph D ,
IRA M VENTRY, Ph D ,
LYMAN S BARRETT, B A ,
and
GRETCHEN A SKALBECK, M A ,

San Francisco, Calif

The purpose of this article is to clarify and expand information relating to the pure-tone threshold configurations and degrees of impairment observed in patients who present hearing loss of a functional nature The Audiology and Speech Correction Clinic of the San Francisco Veterans Administration Hospital serves as a Veterans Administration referral center for patients with difficult diagnostic problems, many involving functional hearing loss Continued experience with these patients and with routine referrals has provided us with clinical data that illustrate the dynamics of functional pure-tone threshold patterns

Some definitions and a review of pertinent literature are essential to an understanding of the material that will follow A functional hearing loss may be defined as a decrease in auditory threshold without organic basis Pure functional hearing loss is relatively uncommon When a patient presents an organic hearing loss elaborated in magnitude (either consciously or unconsciously) he is said to have a functional overlay to his organically based loss Functional overlay is probably the most prevalent type of functional loss encountered in clinical practice Functional symptoms occur frequently in organ systems that have had genuine pathology, hence it is not surprising to find that the preponderance of functional losses have an underlying organic component, or a history of some complaint relative to the ears

There have been a limited number of published reports

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describing functional hearing loss patterns. Semenov[1] reported that "Practically all cases of psychic deafness have flat audiometric profiles. . . ." Fournier[2] reported a flat pure-tone threshold configuration as typifying "malingering." Doerfler,[3] however, observed that 80 per cent of the functional cases in his experience presented a "saucer-shaped" audiometric pattern rising at both ends of the audiogram and lying between 50 and 90 db. He attributed this phenomenon to adherence to an equal-loudness standard. Johnson, Work and McCoy[4] pointed out that the functional saucer audiogram is not so prevalent as Doerfler had indicated, and that it appears primarily in patients who have no significant organic hearing loss, or in cases where there is a conductive loss underlying the functional component. Carhart[5] recently observed that ". . . a trough-shaped audiogram which tends to follow an equal-loudness curve, *i.e.*, an equal phon contour, immediately suggest (sic) the possibility of a non-organic hearing loss." It should be noted that in the frequency range usually measured clinically the phon contours do not strongly resemble saucers. The essential point here is that the patterns described above as characteristic of functional hearing loss were attributed to adherence to an equal-loudness standard.

ORGANICALLY-BASED SAUCERGRAMS

It is important to maintain proper perspective and recognize that the audiometric patterns just described appear clinically on a purely organic basis. Several examples should illustrate this point. The first example (see Fig. 1, Case B.L.) is that of a 42-year-old white male who experienced a rapid unexplained perceptive hearing loss in his left ear. The right ear remained normal. Stenger and galvanic skin response (GSR) procedures corroborated the organic nature of the loss. The air-conduction audiogram of his left ear is similar to the functional pattern described by Doerfler. The second example (see Fig. 2, Case G.B.) is that of a 39-year-old white male with bilateral labyrinthine hydrops. The threshold configuration of his right ear shows a perceptive loss of the type described by Johnson, Work and McCoy. The third example (see Fig. 3, Case D.O.) is that of a 38-year-old white male with a mixed perceptive deafness secondary

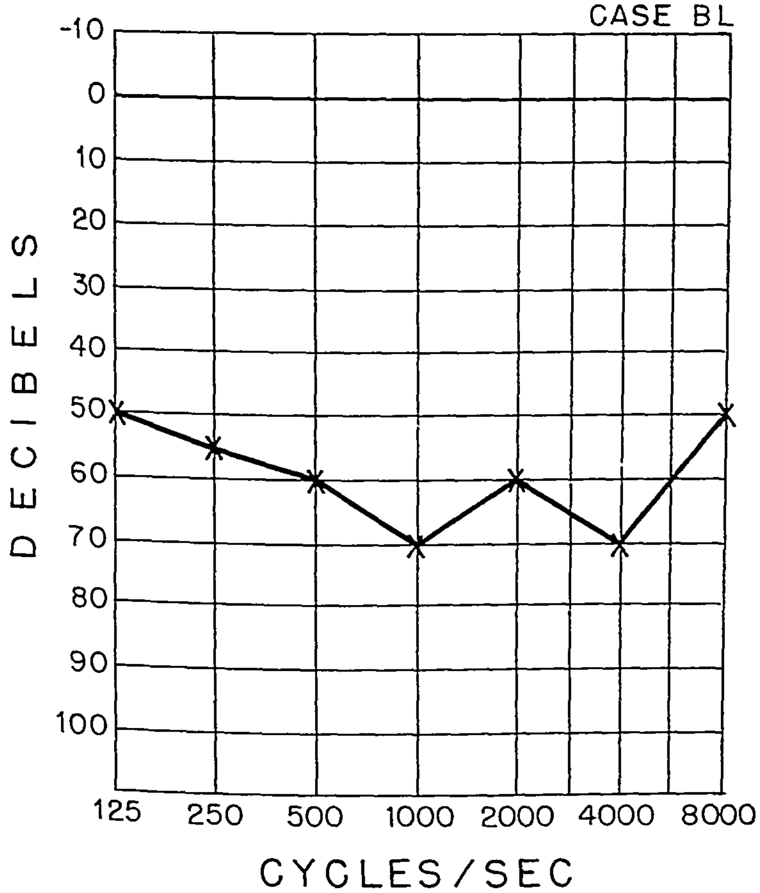

Fig 1 Case B L Unexplained perceptive loss

to advanced otosclerosis The saucer-shaped audiogram of his left ear and the first two examples suggest that the shape of the audiometric curve is probably a poor single index of the presence or absence of a functional hearing loss GSR audiometry at 1,000 cps confirmed the organic nature of the loss in each of these cases An analysis of the functional cases in our clinic files revealed that only seven out of 190 ears (3 7 per cent) had pure-tone threshold patterns that were saucer-shaped Saucergrams represent only one of the many audiometric patterns that may appear in patients who present a functional type of hearing loss

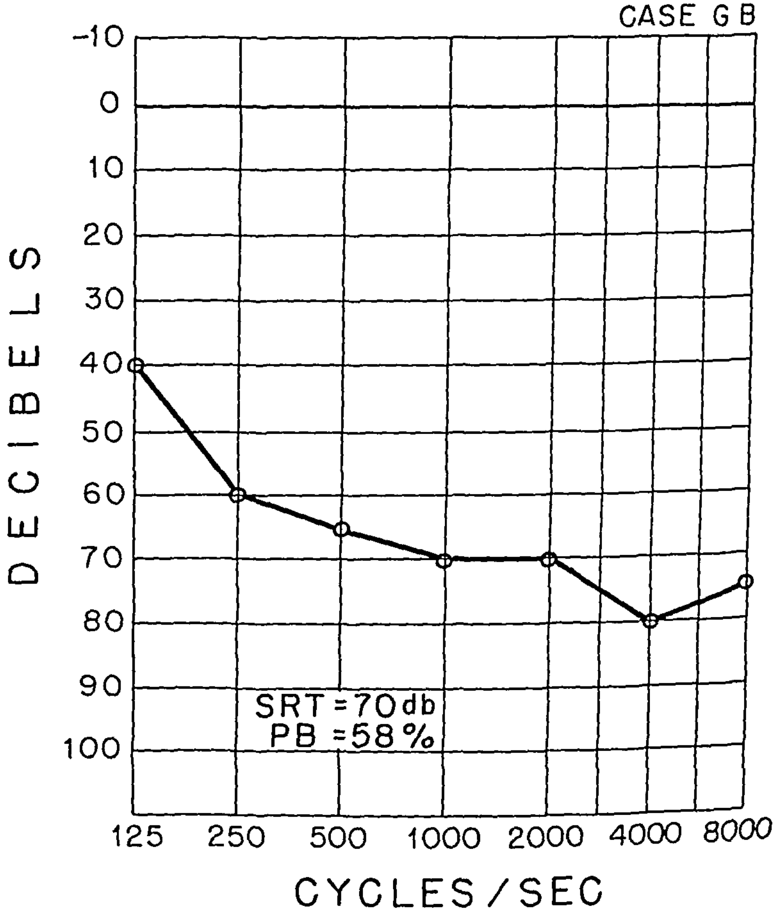

Fig 2 Case G B Labyrinthine hydrops

FUNCTIONAL PURE-TONE CONFIGURATIONS IN THE PRESENCE OF CONDUCTIVE LOSS

In the assessment of routine cases we conduct GSR audiometry at 1,000 cps In the assessment of functional cases, however, GSR audiometry is conducted at 500, 1,000 and 2,000 cps, and in some cases at 4,000 cps GRS audiometry for all cases reported in this paper employed strict conditioning and response criteria with independent analyses of GSR graphic records by two audiologists GSR testing has produced data illustrating some of the basic relationships between

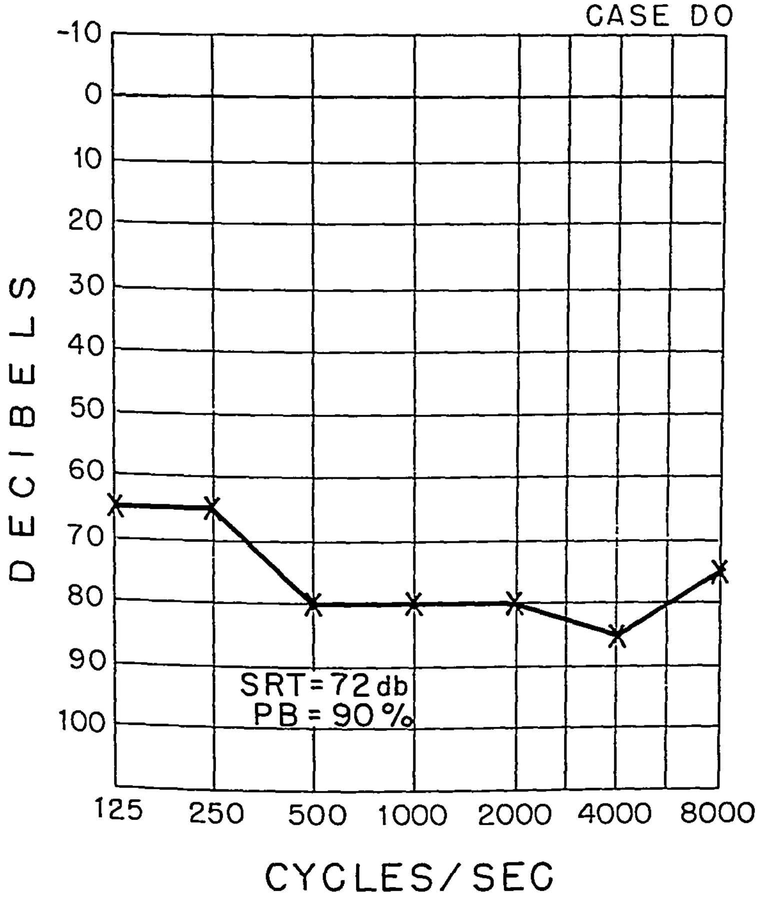

Fig 3 Case D O Mixed perceptive deafness secondary to advanced otosclerosis

type of organic loss, extent of functional component, and shape of the audiometric curve An examination of some of these cases should help to illustrate some of the variables that operate in functional hearing loss

The two cases that follow indicate that pure-tone audiometric patterns other than saucergrams occur in the presence of flat conductive hearing loss This is contrary to the hypothesis advanced by Johnson, Work and McCoy

The first of these cases is that of a 42 year old white male laborer with a childhood history of painful otitis media and a reported decrease in

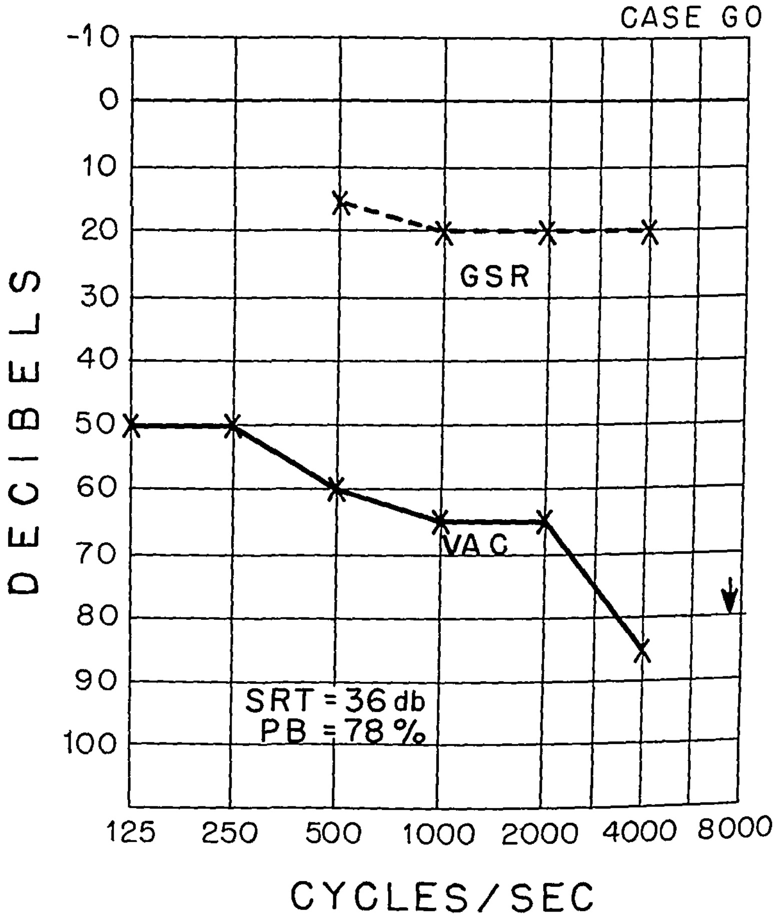

Fig 4 Case GO Drop at 4 000 cps in voluntary air-conduction curve (VAC) with flat organic base (GSR)

hearing on exposure to mortar fire during service Physical examination revealed slightly scarred drums with calcific plaques GSR audiometry (see Fig 4, Case GO) shows a bilateral minimal decrease in hearing acuity Considering the medical history it is likely that in the range measured by GSR the loss is a flat conductive loss, yet his voluntary air conduction curve at 4,000 cps falls rather than rises The speech reception threshold (SRT)* shown in Fig 4 for this case is considerably lower than the average loss in the speech frequencies We have found this to be a typical intertest relationship in patients with functional hearing loss We have, then, an example of a gradually falling curve in the presence of an essentially flat organic base

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*SRTs reported in this article were assessed with the CID W-1 spondaic word lists and intelligibility was measured with the CID W-22 word lists SRTs and PB scores were obtained at the time of the first pure-tone audiogram

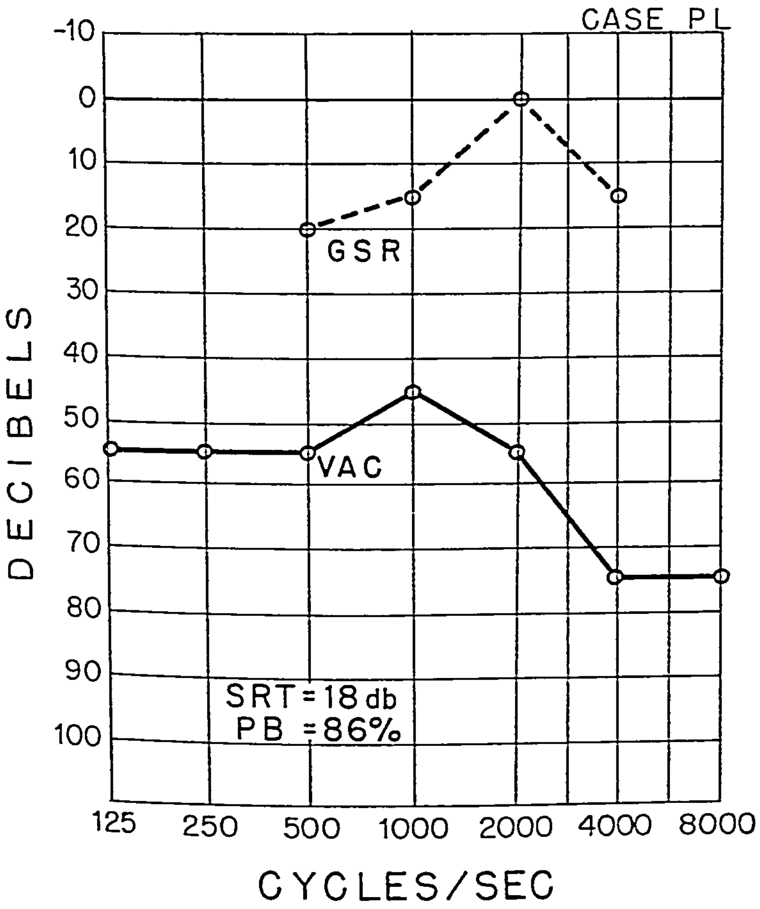

Fig 5 Case P L. Sloping voluntary air-conduction curve (VAC) with conductive organic base (GSP)

The next case (see Fig 5 Case P L) illustrates a similar situation in a 22 year-old white male farm worker with a bilateral functional overlay Medical examination revealed both tympanic membranes were scarred and each had a large central perforation covered with a thin pseudomembrane retracted against the promontory The GSR thresholds for his right ear demonstrate an essentially flat loss (excluding 2 000 cps) which is probably conductive in nature The voluntary pure-tone audiogram is relatively flat until it drops 20 db at 4 000 cps without any apparent underlying organic basis for such a drop

THE LIMITING EFFECTS OF RECRUITMENT ON THE EXTENT OF FUNCTIONAL OVERLAY

Johnson and his colleagues described the effects of recruit-

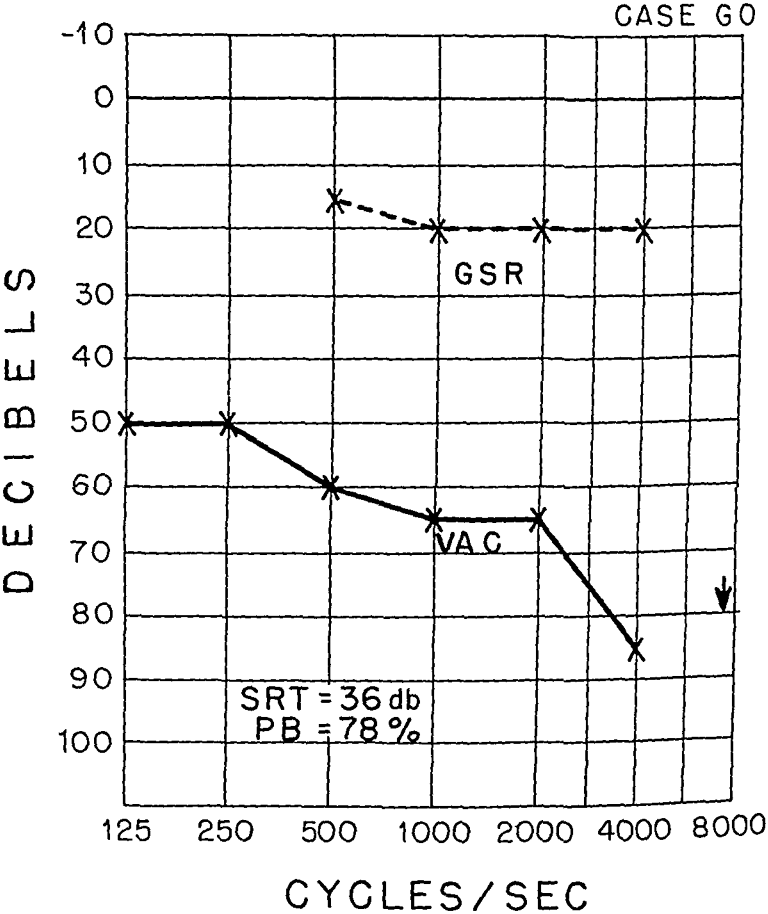

Fig 4 Case G O Drop at 4 000 cps in voluntary air-conduction curve (VAC) with flat organic base (GSR)

hearing on exposure to mortar fire during service Physical examination revealed slightly scarred drums with calcific plaques GSR audiometry (see Fig 4, Case G O) shows a bilateral minimal decrease in hearing acuity Considering the medical history it is likely that in the range measured by GSR the loss is a flat conductive loss, yet his voluntary air conduction curve at 4,000 cps falls rather than rises The speech reception threshold (SRT)* shown in Fig 4 for this case is considerably lower than the average loss in the speech frequencies We have found this to be a typical intertest relationship in patients with functional hearing loss We have, then, an example of a gradually falling curve in the presence of an essentially flat organic base

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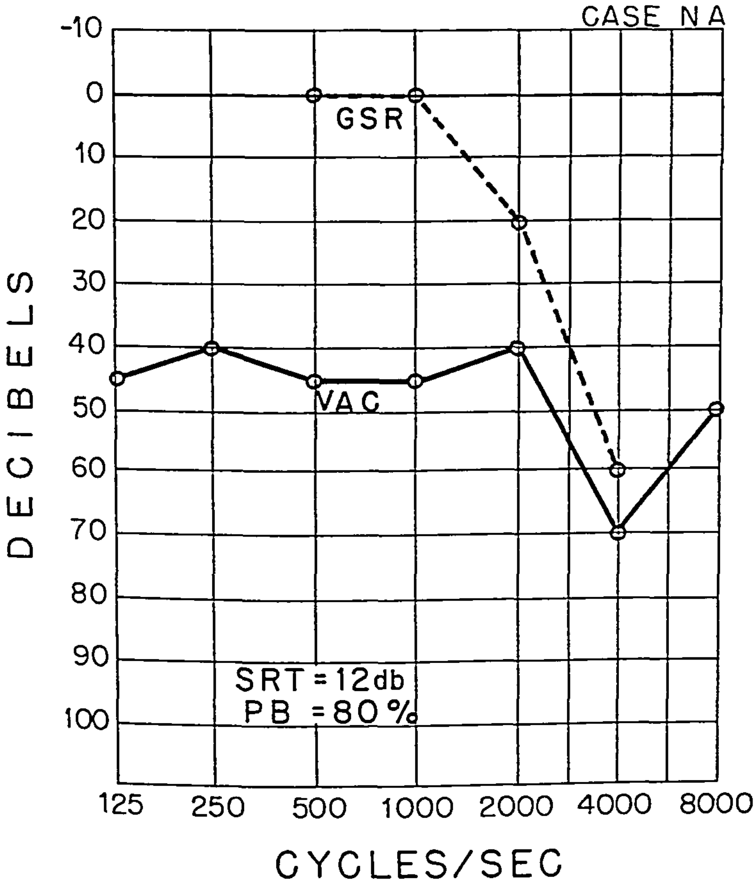

Fig 6-b Case N A Possible relationship between degree of recruitment and extent of overlay illustrated by differential in overlay at 2 000 and 4 000 cps VAC = voluntary air-conduction

The first example is that of a 40 year old white male who gives a history of being thrown into the air by a large demolition explosion after which he reported bilateral tinnitus severe hearing loss in his left ear and relatively normal hearing in his right ear The psychiatric diagnosis in his case was schizophrenic reaction paranoid type in almost complete remission His otological diagnosis was high tone perceptive hearing loss secondary to blast injury with functional overlay In the discussion of audiometry for this and succeeding cases a basic assumption is that in the presence of perceptive hearing loss recruitment is a plausible explanation for the narrowing of functional overlay particularly at the higher frequencies An examination of the left ear test results (see Fig 6 a Case N A) of this patient shows that in the lower frequencies there is a 55 db functional overlay yet at 2 000 cps there is only a 10 db overlay and at 4 000 cps the overlay is only 5 db At both of these frequencies the loss appears to be perceptive in nature and the phenome-

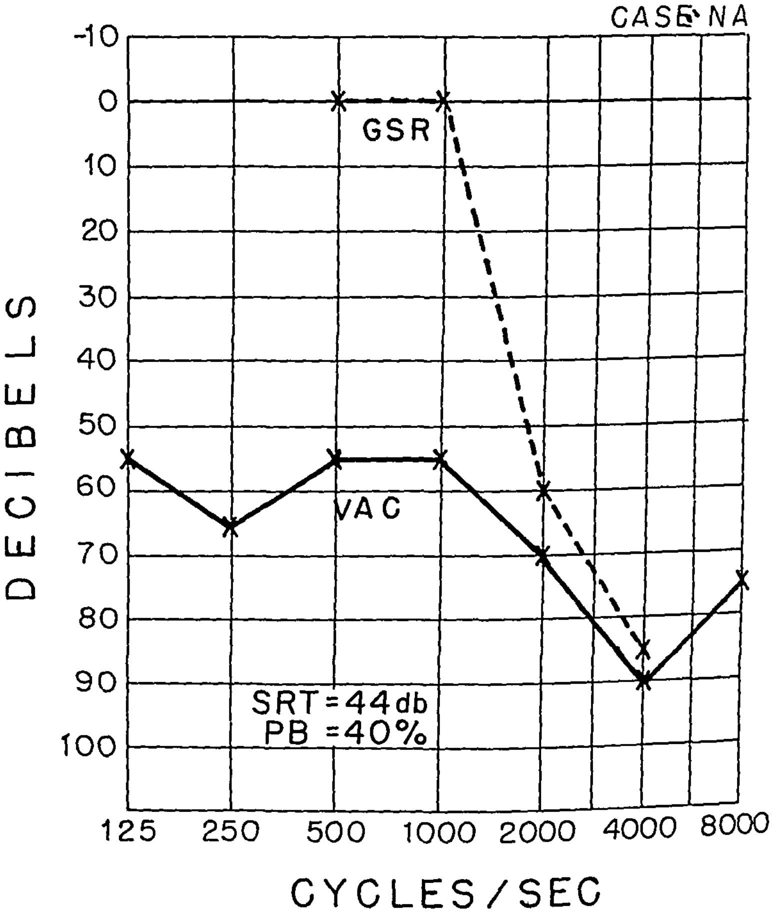

Fig 6-a Case N A Restriction of overlay at 2 000 and 4 000 cps where voluntary air-conduction thresholds (VAC) approximate GSR thresholds

ment in limiting the extent of overlay at frequencies where there is a significant perceptive component to the loss In their discussion of this phenomenon they expressed the opinion that the shape of the saucer audiogram is obscured in the presence of high-frequency perceptive loss GSR audiometry offers an opportunity to provide objective evidence that *functional overlay is restricted in the presence of perceptive* hearing loss marked by recruitment The cases presented in this section will offer supporting evidence for this hypothesis

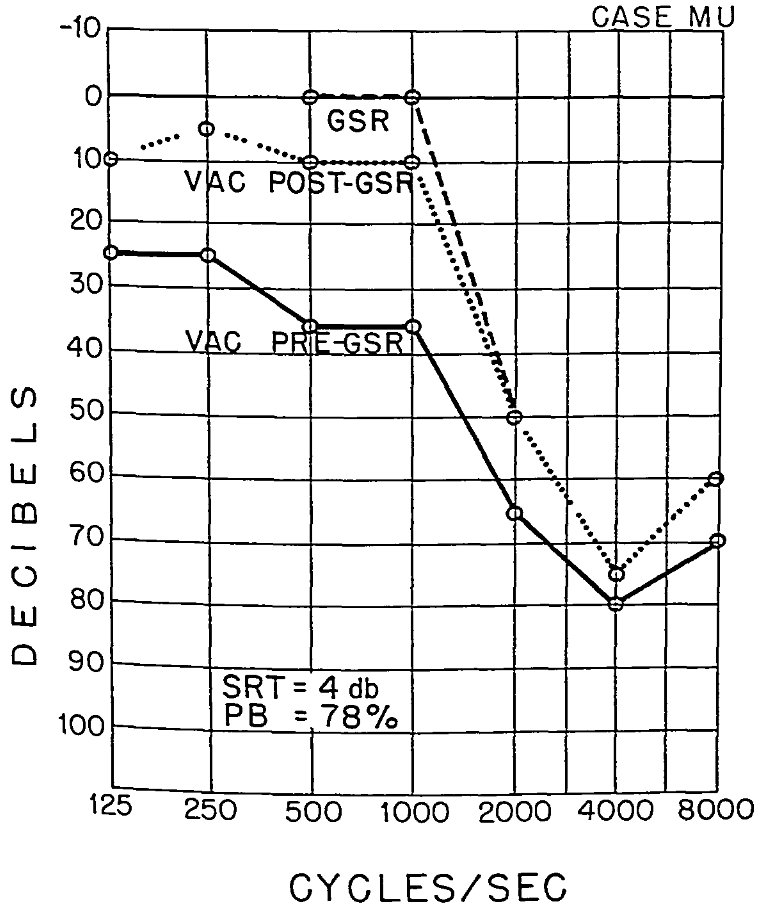

Fig 8 Case MU Change in voluntary air-conduction (VAC) response after GSR and counseling illustrating small changes at higher frequencies

is primarily perceptive in nature with a small conductive component At 250 cps it can be seen that he has a 50 db overlay while at higher frequencies the overlay is only half as great This can probably be explained on the basis of greater perceptive involvement and greater recruitment at frequencies above 250 cps

The next example demonstrates a change in voluntary response after counseling The patient, a 45-year-old white male gives a history of having been an aerial gunnery instructor for 18 months during World War II Physical examination was essentially negative and the final diagnosis was bilateral perceptive hearing loss due to acoustic trauma with mild functional overlay It can be seen (see Fig 8 Case MU) that the post GSR voluntary thresholds still reflect a small overlay at 500 and 1 000 cps but the gap is closed completely at 2 000 cps where recruitment might have restricted the initial overlay While the magni

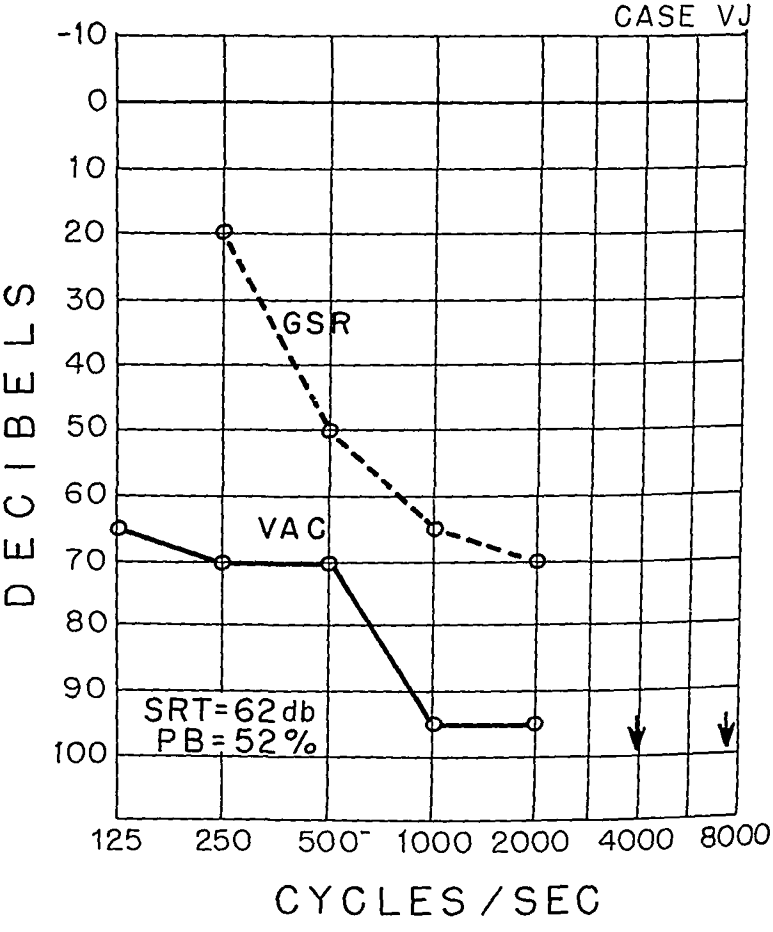

Fig 7 Case V J Possible relationship between degree of recruitment and extent of overlay illustrated by smaller overlay at frequencies with greater preceptive involvement (500-2 000 cps) VAC = voluntary air-conduction

non of recruitment probably causes stimuli to be perceived as relatively loud just above threshold There may be complete recruitment at 4 000 cps in this case An examination of his right ear thresholds (see Fig 6 b, Case N A) suggests that the degree of recruitment influences the amount of functional overlay At 2 000 cps the perceptive decrement is only 20 db, and while some limiting effects of recruitment appear to be present, the decrease in the extent of functional overlay is not so marked as it is at 4,000 cps It is probable that a lesser degree of recruitment was present at 2,000 cps

The next case illustrates a more complicated relationship in a 43 year old white male janitor with a bilateral mixed perceptive hearing loss chronic severe bilateral otitis externa a history of suppurative otitis media, and a functional overlay His hearing loss (see Fig 7, Case V J)

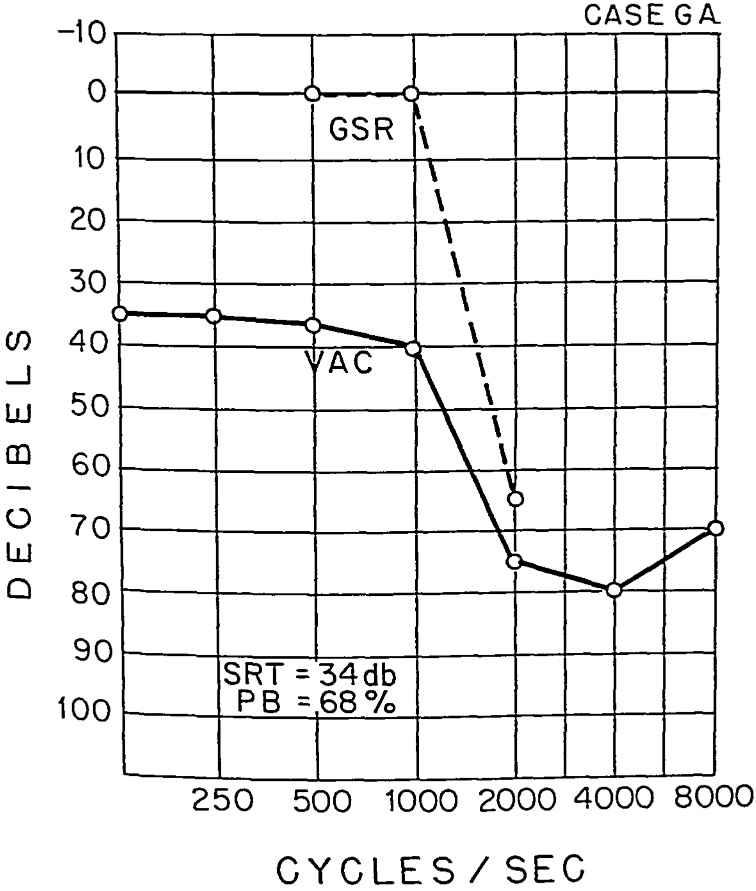

Fig 10 Case G A Minimal overlay at 2 000 cps indicates presence of recruitment (see Fig 11)

post GSR curve corresponds very closely with the pre-GSR curve a plausible result in the presence of recruitment

The last example clearly illustrates the relationship between recruitment and the extent of functional overlay The patient is a 39 year-old male who traces the onset of his loss to a gun muzzle explosion in 1945 Immediately following the explosion he complained of total deafness and severe tinnitus Both symptoms gradually improved but still remain problems The ENT examination was essentially negative GSR findings for the right ear (see Fig 10 Case G.A) reveal normal hearing at 500 and 1 000 cps but a 65 db loss at 2 000 cps The overlay then is 35 and 40 db at 500 and 1 000 cps respectively, but only 10 db at 2 000 cps After counseling the patient's voluntary thresholds improved to such an extent that a loudness matching procedure was thought feasible The results of this test (see Fig 11) indicate complete recruitment at 2 000 cps in the right ear Essentially the same results as described above

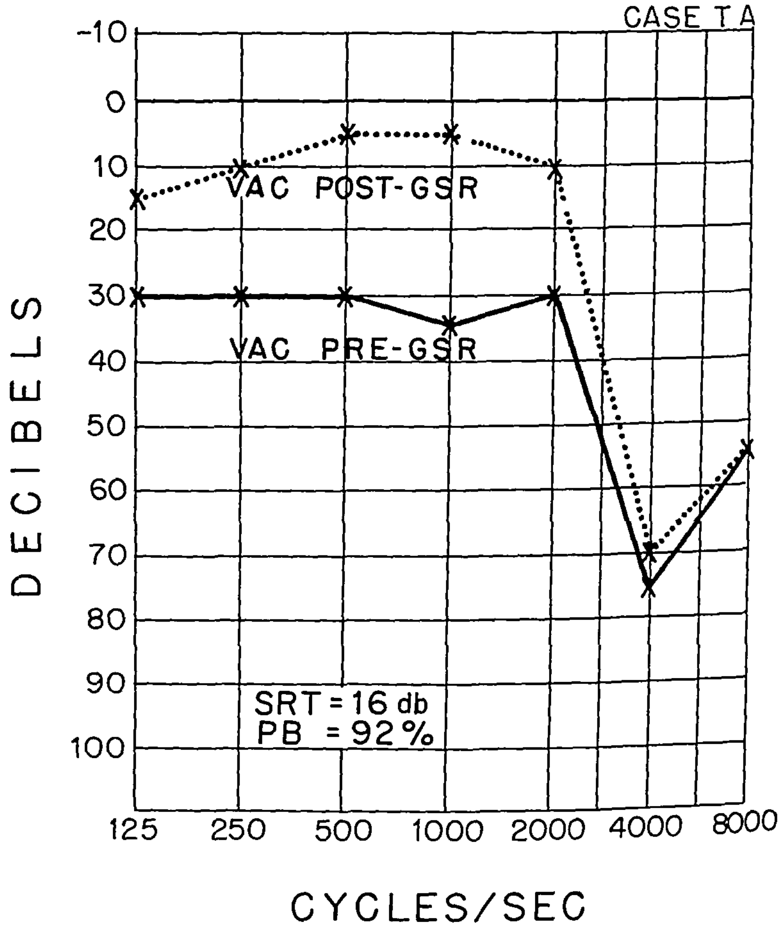

Fig 9 Case T A Change in voluntary response after GSR illustrating close correspondence between pre- and post-GSR voluntary air-conduction (VAC) patterns at 4 000 and 8 000 cps where one might expect recruitment

tude of the initial overlay in this case was relatively small at all frequencies tested, the least amount of overlay occurred at 2 000 and 4 000 cps—15 and 5 db respectively

The stimulus situation of GSR audiometry occasionally results in a remission of functional symptoms The following example illustrates this phenomenon in a patient after an unsuccessful conditioning attempt in GSR audiometry The patient a 36 year old white male, dates the onset of his hearing loss to 1945 when he was blown out of a tank by an explosion which knocked him unconscious and left him with multiple shrapnel injuries At the time of his last examination ENT findings were negative It can be seen (see Fig 9, Case T A) that at 4 000 and 8,000 cps, where one might expect some perceptive involvement the experience that only a small percentage of functional hearing loss cases have saucer audiograms We have also found that other clinical data can be used far more effectively in the detection of functional involvement

2 There does not appear to be a single pure-tone threshold configuration characteristic of functional hearing loss The diversity of pure-tone patterns observed in functional loss makes it difficult to identify functionality solely on the basis of pure-tone threshold configuration

3 One of the primary limitations in magnitude of functional overlay appears to be the presence of recruitment The cases presented in this article would seem to support this hypothesis Further research in this area should produce a more definitive statement of the mechanisms involved

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5 Carhart R Audiometry in Diagnosis The Laryngoscope 68 253 279, March 1958

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SIXTH INTERNATIONAL CONGRESS ON DISEASES OF THE CHEST

The Sixth International Congress on Diseases of the Chest will be held at the University of Vienna from August 29 to September 1, 1960

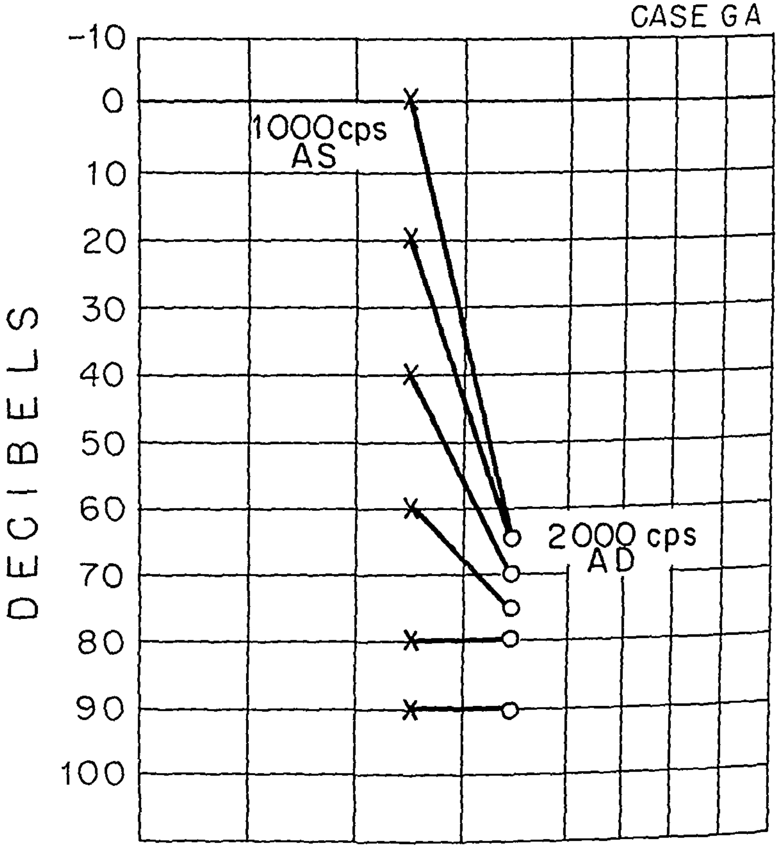

Fig 11 Loudness matching results for Case G A Loudness matches were made between the left ear at 1 000 c p s and the right ear at 2 000 cps

were found for the left ear These results appear to support the hypothesis that recruitment, and perhaps the degree of recruitment, plays a significant role in determining the extent of functional overlay

CONCLUSIONS

Several general statements may be made on the basis of the foregoing information

1 Saucer-shaped audiograms can appear on a purely organic basis It is not well established, furthermore, that the saucer audiogram is the most probable functional pattern in patients with no underlying organic impairment It is our experience that only a small percentage of functional hearing loss cases have saucer audiograms We have also found that other clinical data can be used far more effectively in the detection of functional involvement

2 There does not appear to be a single pure-tone threshold configuration characteristic of functional hearing loss The diversity of pure-tone patterns observed in functional loss makes it difficult to identify functionality solely on the basis of pure-tone threshold configuration

3 One of the primary limitations in magnitude of functional overlay appears to be the presence of recruitment The cases presented in this article would seem to support this hypothesis Further research in this area should produce a more definitive statement of the mechanisms involved

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STAPEDIOPLASTY

A New Concept for Stapes Surgery

ARTHUR L. JUERS, M.D.,
Louisville, Ky.

The recently revived technique for restoring functional stapes mobility in cases of clinical otosclerosis was directed initially toward breaking through the otosclerotic lesion.[1] While a significant number of patients have maintained a serviceable level of hearing following this procedure, initial failure to obtain improvement and subsequent refixation have continued to frustrate the efforts of the otological surgeons. Various modifications of technique have been evolved with the hope of increasing the percentage of lasting hearing improvements. These have included, *1.* perforation (fenestration) of the footplate[2]; *2.* vein graft and polyethylene insert after stapedectomy,[3] and *3.* removal of the stapes crura with fragmentation of the central area of the footplate and insertion of a tantalum pin between the incus and footplate to replace the crura.[4]

The third method, which was conceived by Schuknecht, seemed to be the most logical and least hazardous, but has the objection of having a foreign substance introduced into the middle ear. Schuknecht states, however, that his observations on this method extend over two years, and to date no clinical evidence of intolerance to tantalum has been noted.

It occurred to me that if a precise crurotomy technique could be developed, then one crus could be transposed to a fragmented footplate and a good functional result obtained. This would also bypass the otosclerotic lesion and possibly lessen the likelihood of refixation. Good long range results obtained by me with Fowler's technique[5] in some cases also suggested the feasibility of this new concept. Fowler stated that, in selected cases, the uninvolved posterior half of the

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footplate could be cracked off from the anterior otosclerotic portion after an anterior crurotomy had been performed The patient then has a monocrural structure which, if unimpeded, provides a very satisfactory level of hearing

The chief obstacle was the lack of adequate instrumentarium to carry out precise crurotomy technique Pointed picks were

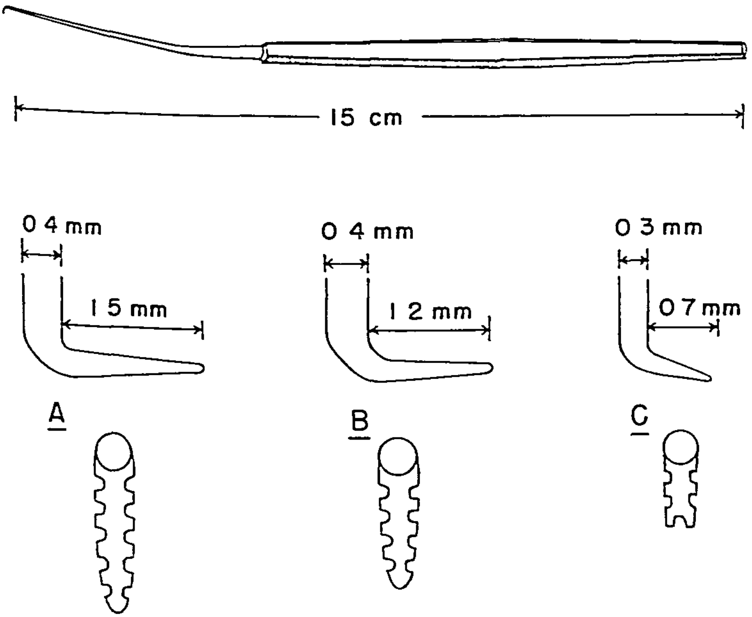

Fig 1 The overall size and shape of a crurotomy saw are shown in the upper part of the illustration A shows an enlarged side and top view of an anterior crurotomy saw with a long blade B shows a slightly shorter one C represents a posterior crurotomy saw It is designed to cut chiefly from the end of the blade The angle between the shaft and blade is about 100 degrees This permits a slight excavating maneuver in separating the crus from the footplate in order to provide maximum length The shaft of each saw is malleable so that it can be bent to the appropriate angle for each case Available from V Mueller & Co

Before the saws are put away after use each blade should be cleaned with a soap solution and very fine brush Otherwise corrosion will occur and cold sterilization may not be effective This cleaning should be done under magnification

sometimes used for this purpose with success, but generally were not adequate because manipulation caused fractures of the crura where not desired Scissors tended to twist and crack the other crus in the wrong place After considerable technical experimentation, I was able to create microscopic *crurotomy saws (see Fig 1)* *This made possible a precise* cut across either one or both crura at the exact point desired

If, on initial inspection and palpation of the stapes, it appears that the otosclerotic fixation involves only the anterior footplate area, and that the posterior portion will mobilize easily, then Fowler's technique can be tried A good separation of the posterior mobile portion of the footplate from the fixed anterior portion should then provide a good hearing improvement This method will be successful in only a relatively small number of cases If it is not successful, then the surgery can be extended to the monocrural transposition technique In cases with extensive vascular otosclerotic infiltration of the footplate, surgical manipulations should be minimal These are best reserved for fenestration

TECHNIQUE

The preliminary medication, local anesthesia and elevation of the tympanomeatal flap to expose the tympanic cavity will not be detailed, since this phase of stapes surgery is fairly uniform as used by various surgeons I use loupe magnification for the flap elevation and then use 16X Zeiss operating microscope magnification for the rest of the surgery It is imperative to remove sufficient meatal bone to provide exposure of the posterior crural area, the stapedius tendon and the edge of the facial canal adjacent to the stapes Careful inspection of the stapes and footplate should then be carried out Any mucous membrane bands or webs which obstruct the view should be separated with an appropriate probe or hook

If the central portion of the footplate appears somewhat bluish and thin, the prognosis of successful surgery is excellent Gentle transincudal manipulation should be tried first Occasionally this will free the footplate and provide a good functional result without further surgery When the footplate is more rigidly fixed and the situation appears favorable for Fowler's technique, then this should be attempted with a crurotomy saw If the posterior crural area is rigidly fixed, then the monocrural transposition technique can be carried out

Steps of stapedioplasty (monocrural transposition)

1 The stapedius tendon is cut to provide better posterior crural exposure and maximum crural mobility

2 An anterior cruiotomy is started with a crurotomy saw (see Fig 2) Delicate, meticulous handling of the saw is imperative if an inadvertent twist fracture of the crura in the wrong place is to be avoided The direction of the movements of the long axis of the anterior crurotomy saw should be oblique (45 degrees) to a plane passing through both crura Direct side pressure (90 degrees) to the crural plane will frequently fracture the crura In using the anterior saw there must be constant vigilance in order to avoid trauma to the facial nerve In some instances the view of the anterior crus is obscured by the incus and capitulum It is then necessary to do the cruiotomy by touch In one instance a short saw was used to approach the anterior crus from its under-

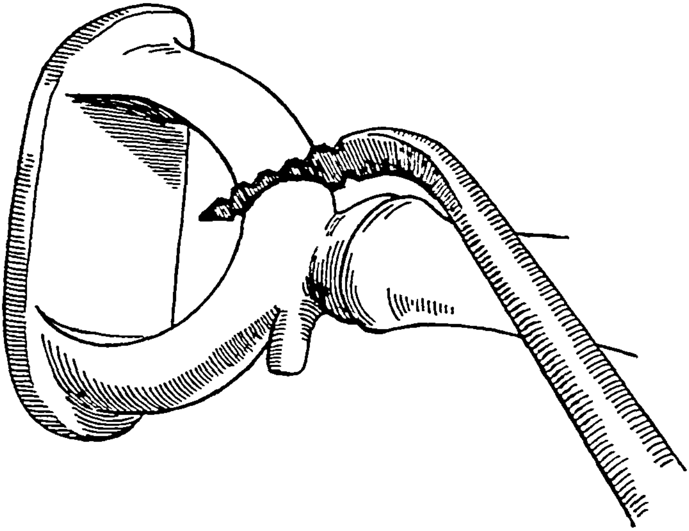

Fig 2 The view of the stapes is represented somewhat more oblique than is true of the actual view obtained at surgery in order that the saw technique can be shown clearly Otosclerotic lesions were not shown in these drawings Whether the approach with the saw is from the superior or inferior aspect of the crus depends on the angle of the particular stapes and its relation to the promontory and facial nerve

neath aspect The shaft of each saw is malleable and can be angled as needed to fit the individual case

3 *Before* the anterior crurotomy is completed, another type of saw is used to cut partly through the posterior crus *as close to the footplate as possible* (see Fig 3) This saw approaches the posterior crus from the anterior-superior or anterior-inferior aspect Cutting partly through the posterior crus at this time will provide a weak place in the posterior crus, and

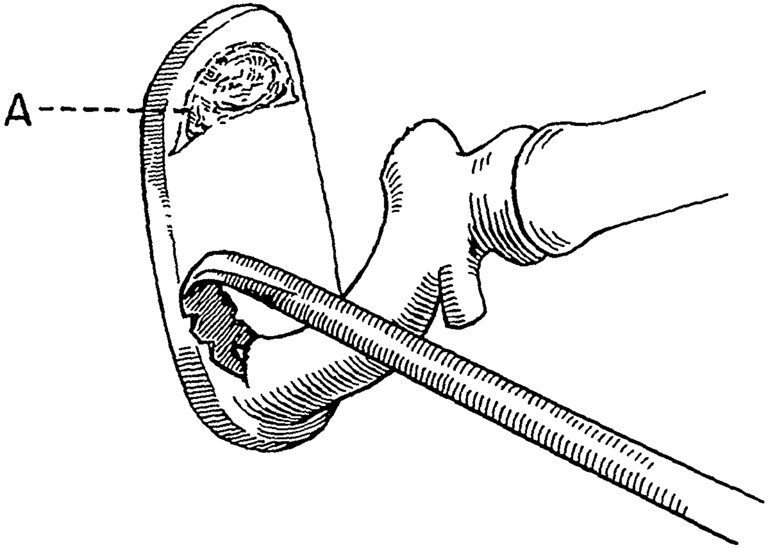

Fig 3 Posterior crurotomy saw in place adjacent to the footplate The approach is usually from the anterior superior aspect of the crus but for diagrammatic convenience it is shown on the inferior side Note the cutting is accomplished chiefly by the end of the saw A shows the stump of the anterior crus

when the anterior crurotomy is completed any inadvertent twist of the body of the stapes will tend to crack the posterior crus at the footplate, thereby providing maximum length

4 After the anterior crurotomy is completed, the remainder of the anterior crus distal to the cut is fractured and removed

5 The posterior crurotomy is then completed with a saw and a right angle sharp probe Intense, prying pressure with a probe behind the posterior crus attachment should be avoid-

ed, because this may fracture the crus a short distance away from the footplate rather than at the footplate

6 The freed posterior crus is now reflected forward to expose the footplate (see Fig 4).

7 Fragmentation of the footplate is now carried out (see Fig 4) This is accomplished with a sharp probe and knife The knife is not used to perforate but merely to scratch the footplate surface in a manner similar to that used in cutting glass Separation of the footplate fragments is unavoidable, and is followed by some escape of perilymph Perforation or penetration into the vestibule is avoided Suction directly on the footplate should now be avoided in order not to remove any excess perilymph *Excessive* inward displacement of footplate fragments is inadvisable A few small dehiscences may be desirable in order to provide more mobility of the fragments Whether a dehiscence decreases the liklihood of refixation remains to be seen

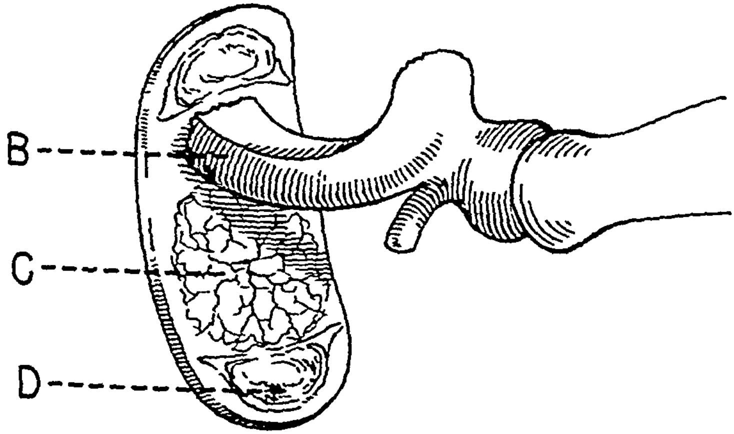

Fig 4 B—Posterior crus reflected forward to expose footplate C—Fragmented area in center of footplate D—Site of posterior crus cut at or below footplate level

8 The posterior crus is now placed over the fragmented area at the point where it seems to establish the best possible contact with the footplate (see Fig 5) In the event that contact is lacking, a minute piece of conchal cartilage might

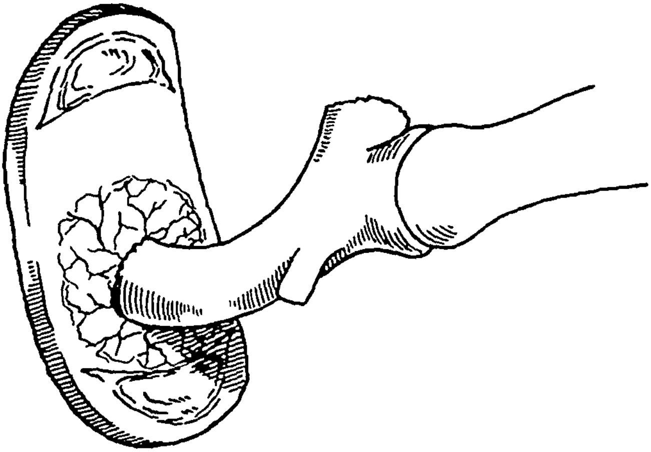

Fig 5 Posterior crus transposed to fragmented footplate at point of optimum contact

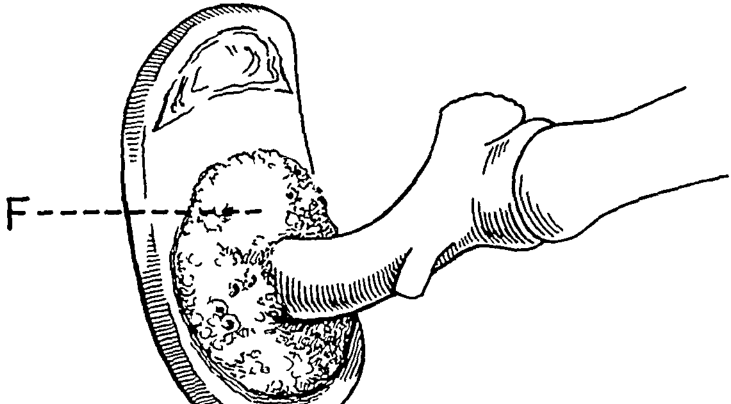

Fig 6 F—Gelfoam placed around transposed crus

be used to fill the gap Meatal bone could also be used, but it might theoretically be more inclined to initiate osteogenetic activity

9 Two or three minute pieces of gelfoam are placed around the transposed crus to hold it in place and seal the perilymph space (see Fig 6)

10 The middle ear is then aspirated to remove any residual blood or fluid The canal anesthesia solution frequently gravitates into the middle ear and should be aspirated at intervals during as well as on completion of the operation The round window membrane is not impermeable to topical anesthesia, and prolonged contact of the solution could conceivably penetrate the inner ear

11 The tympanomeatal flap is placed back in position, and the incision covered with a few pieces of gelfoam

If the posterior crus is involved in otosclerotic fixation and the anterior crus and adjacent footplate are not involved, then a posterior short crurotomy can be done and the anterior crus transposed to the fragmented footplate This situation occurred in one case

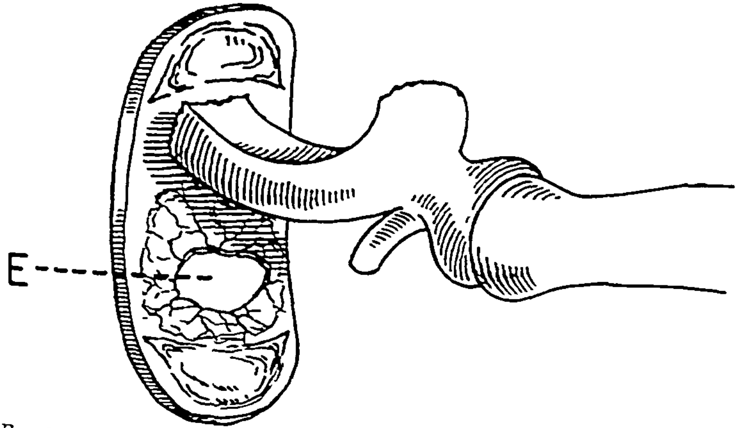

Fig 7 E—Dehiscence created in center of fragmented area Posterior crus to be placed over this footplate opening

There are occasional instances in which the facial nerve is so close to the promontory that there is space for only the crura The bony canal over the facial nerve at this point is frequently absent in such cases It is impossible to view the footplate in such situation and no direct footplate surgery is possible

RESULTS

I have used the stapedioplasty (monocrural transposition) technique on ten patients to date (cases 1-10, see Fig 8), the first one having been performed in September, 1958 The *lower end of the arrow shows the preoperative speech fre*quency pure tone average, and the arrow point indicates the optimum level attained after surgery, usually one or two weeks postoperative It will be noted that the air-bone gap

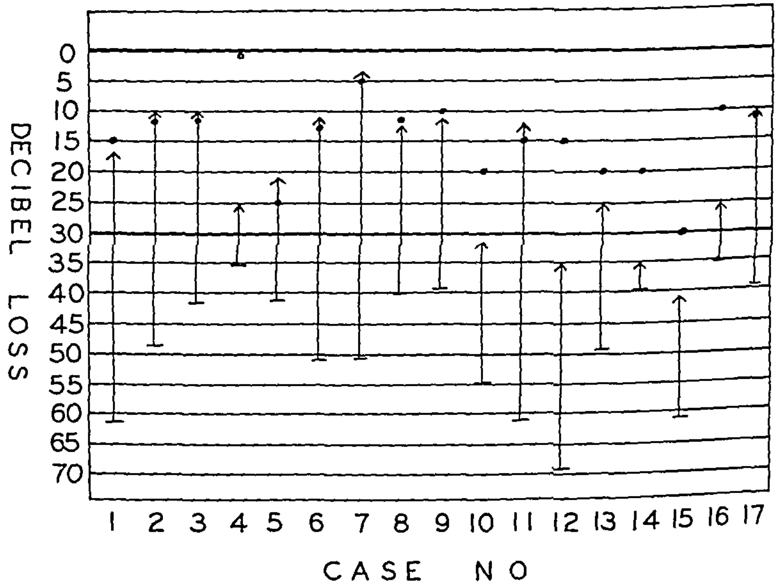

Fig 8 This chart shows the pure tone threshold average for the 500 1 000 and 2 000 frequencies on 17 most recent cases of stapes surgery The solid dot represents the preoperative bone conduction threshold The horizontal bar at the lower end of the vertical line indicates the preoperative *air conduction threshold* The *arrow point at the top* of the line shows the best early postoperative air conduction threshold This was usually obtained two or three weeks after surgery Cases on which satisfactory monocrural transposition was accomplished are grouped in the first 10 shown Other techniques are grouped in 11-17 as discussed under the section Results”

has been eliminated in all cases except Nos 4 and 8 In Case 4 the footplate was somewhat thick, even though it appeared somewhat bluish This was one of the early cases, and subsequent experience would indicate that the amount of fragmentation accomplished was inadequate *If the improved level* of hearing is not maintained, the operation can be revised, and the degree of fragmentation increased

In the process of fragmenting the footplate, it is impossible, with the present technique, to avoid creating a small dehiscence in addition to the minute punctures What influence this may have on the permanency of fragment mobility remains to be determined In reporting on their histological examination of a case of otosclerosis 15 months after stapes-mobilization operation, Altman and Basek[4] report as follows

"The tear in the endosteum healed completely, and the defect in the footplate was filled with a layer of connective tissue There is very little reaction and definitely no bony callus formation around the broken pieces of the footplate, and callus formation is also absent in the fractures through both stapedial crura The latter consist of skein-like bone

"The absence of labyrinthine reactive changes, particularly the absence of connective tissue proliferation around the bone chip sticking into the lumen of the vestibule, is noteworthy It is, in all probability, the result of the prevention of a postoperative infection by tetracycline"

In view of this observation, the possibility that some dehiscence could increase the probability of permanency of mobility must be considered

In Case 10 I purposely created a footplate opening in the area of fragmentation, and placed the transposed crus over this opening and packed gelfoam around the crus (see Fig 7) There was considerable postoperative tinnitus, and the hearing test four days after surgery showed less air conduction improvement than has been observed in most of the other cases, in addition, there was a slight depression of bone conduction acuity for the higher frequencies

The permanency of the results obtained by the monocrural transposition technique must await the passage of time Case 1 has maintained a 20 db level at three months after surgery Case 2 has a 15 db level at two months The remaining cases have had only six weeks' or less follow-up at the time of writing

In Cases 11 and 12 the nature of the pathology was such that the longest crus obtainable did not reach the footplate, in fact, in each instance only half a crus-length was available A small piece of meatal bone was inserted between the end of the crus and the footplate Whether this bony insert will stimulate osteogenesis and refixation cannot be stated at present Possibly a small piece of conchal cartilage would be preferable to bridge the gap In Case 11 the functional result was satisfactory, but in Case 12 it was not

I plan to revise Case 12, remove the remains of the stapes and create a new "stapes" out of conchal cartilage It should be possible to cut such a structure under 16X magnification A small hole near one end perpendicular to the long axis of the new stapes would permit it to be pushed onto the incus This would prevent penetration of the "fabricated stapes" into the perilymphatic space of the vestibule It is my feeling that, in instances where a crural transposition cannot be accomplished for technical reasons, autogenous tissues should, if possible, be used to establish functional ossicular continuity The alternative to this is to use an insert such as tantalum or polyethylene

In Cases 13 and 17 the entire stapes was easily mobilized, and the crura were not cut In Case 14 there was considerable otosclerotic infiltration of the footplate and only minimal mobility was obtained In Case 15 a monocrural transposition was planned, but an attempt to loosen the posterior crus from the footplate by prying behind the crus caused a fracture of this crus in its mid-portion This made transposition impossible, and a Fowler type of operation was carried out It was not possible to overcome fully the impedance to good mobility In Case 16 a fair degree of preoperative ossicular function was present before surgery, and it was not deemed justifiable to use the crural transposition technique

DISCUSSION

When the entire stapes footplate cannot be easily mobilized, the ideal technique would seem to be one which would bypass the otosclerotic lesion and yet maintain some type of ossicular functional continuity with a mobile section of the footplate, without penetrating or disturbing to an appreciable degree the contents of the vestibule of the labyrinth Fowler's technique was the first to be directed toward this objective, however, even in seemingly suitable situations, the area of the posterior crus may be fixed, even though there is no gross evidence of otosclerotic fixation at this point on inspection

In the technique described by Schuknecht, the central thin area of the footplate is fragmented, the stapes crura are removed and functional continuity established by the insertion of a fine tantalum wire between the incus and the fragmented footplate Disturbance of the vestibular contents here is minimal, but the theoretical objection to the introduction of a foreign substance has been raised, however, as far as is known, tantalum is well tolerated in all tissues

Shea has evolved a technique in which he removes a large segment of, or the entire footplate and both crura He seals the oval window with a vein graft, and inserts a polyethylene tube between the incus and the invaginated vein graft This obviously creates considerable disturbance of the vestibular contents Long range tolerance of polyethylene exposed in the tympanic cavity in this manner remains to be determined Wullstein has stated that, in his experience, plastic prostheses used in tympanoplasty surgery are eventually rejected by the tissues, however, the plastic material he used was not polyethylene

The stapedioplasty technique described by the author employs the footplate fragmentation principle of Schuknecht, but instead of using a foreign substance for restoring functional continuity, utilizes precise crurotomy and monocrural transposition for re-establishing ossicular continuity Hearing improvements obtained by this technique in a small series of cases have surpassed results obtained by previous methods in the author's experience

An improvement in the means for fragmenting the footplate is needed Further refinement of instrumentation is possible If the mucous membrane on the footplate could be elevated before fragmentation is started, then the membrane could be rolled back on completion of the fragmentation and serve to seal the perilymph space This might also lessen the tendency toward scar tissue formation around the footplate fragments A microscopic knife and elevator are being developed for this purpose. An incision through the mucous membrane between the crural sites with elevation away from this line should encounter very little bleeding.

Whether gelfoam is the best material to pack around the transposed crus is to be considered. Small pieces of tympanic mucosa from the promontory could be considered for this purpose. If the transposed crus maintains its new position, no packing at all may be needed.

If there is eventually any tendency toward refixation of the footplate fragments, creating a larger dehiscence and covering this opening before transposing the crus should be considered (see Fig. 7). A small piece of thin perichondrium could be easily obtained for this purpose and placed under the mucous membrane flap. A vein graft as used by Shea could be similarly utilized, however, obtaining a vein graft adds to the complexity of the operation.

It should be pointed out that if crural transposition is used as a salvage procedure after inadvertent fracture at points other than those indicated in the section on technique, then optimum results cannot be anticipated. If, after initial inspection of the stapes, monocrural transposition seems to be indicated as previously discussed, then the technique described can be carried out precisely, and a high degree of predictability of hearing improvement should be possible.

SUMMARY

1. A new technique for stapes surgery in clinical otosclerosis is described. It incorporates the following features:

    a. The new conduction pathway bypasses the otosclerotic lesion.

    b. Re-establishes functional ossicular continuity by monocrural transposition.

2. The hearing improvement to be anticipated seems to be highly predictable in properly selected cases as determined by initial inspection and palpation of the stapes at the time of surgery.

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THE BIOCENOLOGIC APPROACH TO BLACK HAIRY TONGUE WITH NEW CONCEPTS OF ITS TREATMENT [*]

Secondary Mycosis Linguae of Pathologic Significance

MERRILL LINEBACK, M D ,
College Park, Ga

The present study of nine case reports and analysis of 118 related cases of "coated" tongue varying from white, patchy to yellow-brown, is the culmination of three years consideration of the problem of the etiology and treatment of *black hairy tongue*, and a search for a unifying concept that would explain all of the various manifestations and apparently conflicting ideas about the disease The author's own concepts have been variously hit-and-miss, until early 1958 when fruitful crystallization of the parameters appeared in two timely articles, one by Winer[1] and the other by Makower [2] The latter is the more valuable of the two, with the discussion of *biocenosis* which, for the present author, contains the unifying concept so long sought Both articles will be considered in more detail further on in this paper Other acute and chronic diseases, often involving coating of the tongue, are not related to the entity under discussion and will not be considered here These include leucoplakia, phenol poisoning, scarlatina, acute tonsillitis, typhoid fever, typhus, measles, and Vincent's angina First, it would be valuable to mention what has been done up to now in the attempt to analyze the entity of *black hairy tongue*

HISTORICAL

Heidingsfeld[3] in 1910 was the first to review the literature on the subject, and he credits Rayer with the original description of the disease in 1835 At this time (1910) the etiology was considered of two types a *true* hairy tongue

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[*] Read at the meeting of the Atlanta Eye Ear Nose and Throat Society

Editor's Note This manuscript received in The Laryngoscope Office and accepted for publication Jan 19 1959

that originated as an anomaly of development from embryonic life and developed later, possibly confined to definite areas of the tongue dorsum, and a *false* hairy tongue that owed its origin to local irritation, infection, tobacco, antisepsis or syphilis In his Case 1, Heidingsfeld described filaments projecting from the dorsum of the tongue which could often be traced to an origin from papilla-like sites in the stratum corneum These filaments often preserve a feather-like appearance Another characteristic is the formation of abnormal papilla-like bodies, or epithelial nests, which he called "epithelial founts " A more accurate description of the pathology is that of Laskaris and Curtis[4] in 1949, who describe filiform papillae which have the superficial appearance of hairs One has only to recall their ectodermal origin The feathery nature of the filaments is important in serving to trap micro-organisms, food particles and tobacco stains, much as the baleen of the right whale traps crustaceans for its nourishment This aspect will be considered in more detail later

Pillsbury[5] in 1956, described the clinical picture as being made up of brown to black pseudopapillae confined to the posterior half of the tongue dorsum He considered the etiology to be as yet unproven

Kleinert[6] in 1946, thought the etiology was due to excess tobacco, and was unable to effect a cure with large doses of penicillin

Layne and Watson[7] in 1941, caused a deficiency of nicotinic acid in dogs and developed lesions on the tongue similar to black tongue in the human They also postulated a relation of black hairy tongue to human pellagra

Weidman[8] in 1928, reviewed the literature and found one case associated with diabetes It is noteworthy that all the teeth had been extracted years prior to development of the black tongue in this case

In a survey of the literature in 1949 Laskaris and Curtis[9] found a more or less definite floral association in BHT micrococci, alpha hemolytic streptococci, gram negative diplococci, leptotrichia, monilia, and actinomyces-like organisms, filiform

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the keratosis. Montagna[12] in 1956, reported on the enzymatic hydrolysis by crop juices of ingested keratin in the hawk and vulture. This observation will have bearing in the discussion later involving *biocenosis*.

This brings the discussion up to the present time, and for the most part authors who have written on the subject have limited their presentations to the tongue alone, forgetting that the part is not the whole, and not seeing the tree for the moss, as it were. For the fully developed picture of BHT resembles nothing so much as a dense growth of moss on a tree trunk. What is more important though, is the fact that the patient himself is directly concerned about his state of nutrition and resistance, for example. Not just one isolated tissue or organ is to be considered in BHT, but the entire patient himself. The general tendency in medicine today is to treat symptoms and overlook the needs, pathology and treatment of the whole patient, despite the warnings of advanced medical circles. The concept of the whole patient must be extended to his family, neighborhood, community, region and finally to the nation, yes, and to the world as a unit. Herein lies the proposed value of the concept of *biocenosis* as noted by Makower[13] in 1958, coming from the Greek, *koinos*, meaning common or that pertaining to the community, population, or public. In more specific terms, it means a biologic community or population and the relationships of all members, both *macro* and *microscopic*. The term is similar to *ecology*, but this latter has a more limited meaning derived from the Greek, *oikos*, house. The term *symbiosis*, coined by deBary[14] in 1879, has come to mean predominately mutually useful associations, and Makower, therefore, uses the term *mutualism* for these. Since micro-organisms play a major part in the syndrome of BHT, their relationships as a *microbiocenologic* population on the mucous membrane and epithelium of the upper respiratory and alimentary tract must be considered here.

He notes three types of such relationships between the patient (host) and micro-organisms (guests) as follows (see Chart). *1* When the relation between the two results in damage to the host, or in disease, it is known as *parasitism*, *2* if it results in tolerance, *commensal*, and *3* if both derive bacilli, the proportion varied with the case They conclude, with serious doubt, that there is a parasitic etiology of the condition Some, or perhaps most, of the bacilli and acinomyces-like organisms were found to be *lactobacilli,* in fact, organisms in two out of three cases studied by these authors referable to *lactobacillus acidophilus* were found to be implanted in the hairy tongue filaments The rather consistent presence of aciduric-type organisms indicates they have supplemented normal tongue flora as a result of increased acidity of salivary secretions, their fermentative acidic activities insure a continuous chemical irritation, as noted by Swinburne[10]

MODERN EVIDENCE

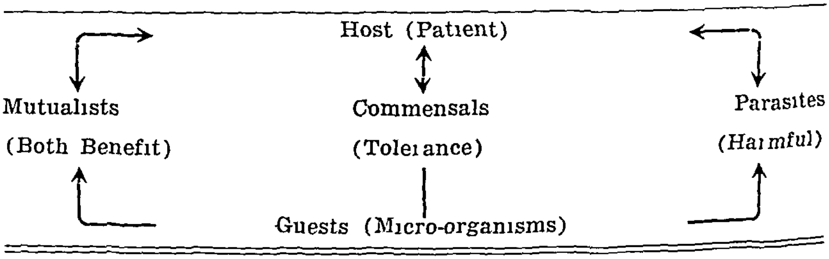
Winer[11] describes the filiform papillae as being grouped in parallel rows across the tongue and as being most numerous of all papillae The epithelial cells covering these form a hollow-shaped cap which normally undergo hyaline degeneration and are cast off In pathologic conditions in man they develop heavy keratin tips, while in animals they are normally so thickly covered with keratin that they add a rasp-like appearance or "feel" to the tongue surface He considers the etiology as made up of various bacteria, fungi, antibiotics, mouthwashes, and nicotinic acid deficiency The pigment is definitely *not* melanin The BHT contains increased keratin with an increased number of *monilia* Through excess acidity keratin is not shed Conversely there is excess shedding seen in the geographic tongue This latter is frequently inhibited with dilute hydrochloric acidification As to the pathology, he found that oral antibiotics may produce epithelial hyperplasia of the filiform papillae, while parenteral penicillin produces a proliferation of the capillary endothelium, an eosinophilic infiltration in the perivascular area of the papillary cutis, and is a pseudokeratosis without hypertrophy of the stratum corneum He also noted that an observed vacuolation of the upper epithelium in sections of BHT was similar to that found in warts He thereupon used a keratolytic, podophyllin locally, and in two weeks was able to control the case described in his interesting article He advocated, in addition, oral troches of vitamin A to inhibit recurrence of with abuse of antibiotics, the immunity state and the nutritional balance of the individual determines the degree of involvement of the epitheliums mentioned above

Sometimes fatal extensions, from pulmonary mycoses to the meninges and encephalon itself, are known to have occurred[15] These variations (see bacteriology) determine the color of the tongue, whether white and patchy, or more diffusely yellow-brown to the diagnostic mossy BHT Along with this lingual picture patches of keratotic vegetations have been found in the pyriform sinuses and even in the nasopharynx BHT is not usually found associated with debilitating disease, such as diabetes or cancer Antibiotics are the major causes of the syndrome, because of the injudicious use and abuse of their known usefulness, in fact, antibiotics themselves may be considered the product of a microbiocenotic relationship, that of antagonistic activities developed in other biocenotic communities, whether in the culture vat or in the human body[16,17] One might, therefore, extrapolate backwards in time and speculate from Urr's finding that skin and hair fungi are able to produce antibiotics, that the etiology of BHT had a basis from the beginning of its description in 1835 (Rayer) in antibiotic activity, long before even the discoveries of Flemming In a word, BHT nowadays may be considered a truly "iatrogenic" disease Finland[18] notes that large doses of tetracyclines may also give rise to sore tongue or *black tongue*, cheilosis and rectal irritation in some patients

The possibility of *mutations* in microbes as a result of acquiring resistance to antibiotics is a question only further research can elucidate Mutation as a result of "fallout" from atomic and nuclear weapons testing is a definite possibility

The public health aspects of antibiotic abuse are illustrated by the A M A Committee on Medicolegal Problems,[19] which reviewed a report in *Veterinary Medicine,* which states that about 6 per cent to 12 per cent of milk reaching the consumer contains penicillin ranging from 2 to 80 units per glass Many of my patients give a history of copious milk consumption, and not a few at one time or another during the winter benefit, *mutual* One may verge gradually over a period of time into another, when antibiotics or other agents destroy the normal flora of the mouth, for instance, there results in the low resistance patient, or in the young or very elderly debilitated one, the acute infection known as "thrush," a parasitism If, in the more resistant individual and in one in a relatively good state of nutrition, the antibiotics merely destroy the sensitive micro-organisms, leaving the resistant ones to develop and eventually "overgrow," then a tolerance is often noted and the commensal relation is seen One often sees cases of "thrush" in children and one or more phases of BHT or other evidence of moniliasis, such as vaginitis or external otitis, in the adults of the family group Frequently seen is external otitis with a concomitant fungus of the tongue in the same individual

CHART I



Adapted from Makower,[2] 1958

Many patients have given the history of antibiotics several years prior to having the BHT or milder modifications thereof uncovered during routine mouth and throat examinations, and they have, until then, been unaware they had a tongue lesion *Upon careful questioning they nearly always admit* having a fetid breath or a "bad" taste in the mouth Such lesions again are frequently noted by patients themselves, and only after careful recollection can they remember ever having had prior antibiotics Only the most hardy of patients have no symptoms with their BHT, the usual finding is that mild to more serious pathology and localizing symptoms are presented The number of invading organisms, or rather the number of resistant ones, which seem to be on the increase across the tongue. Persistence in cleaning is a definite requirement for success, both for the physician and patient. The latter was often instructed to use gauze 4x4s as an aid at home.

After the association of acidophilic bacteria and fungi was noted, strips of pH paper, known as pHydrion strips, and obtained from Micro Essential Laboratories, Brooklyn 10, New York, with a range of 4-9, were used on the tongue when the patient was first seen, and during the phase of treatment. The environment was definitely acid, pH 5 or 6, while normal controls were found to be consistently alkaline or neutral. During treatment with pancreatic enzyme therapy the reaction was also alkaline. It is interesting that confirmation of this pH factor as influencing the presence or absence of fungi was found in a recent communication by Yannoulis in 1957.[20] He was interested in the pH found in laryngeal papillomatosis and found *Monilia* most frequently with an acid pH. The lower the pH the more resistant was the fungal condition to treatment. The present writer has noted a tendency to this resistance of the lingual cenosis to treatment with low pH, but no definite conclusions can be reached at this time.

Among the various chemicals used in the many attempts to clear up lingual coating were: 3 per cent gentian violet, Larylgan,® Desenex,® Decapryn,® tincture of myrrh, and Cetylcide® in a 1:4 dilution with water.

More recently the alkaline mouthwash Cepacol® has been tried with good results in keeping the reaction in the mouth at a more favorable pH. It is also helpful in combatting the bitter, musky taste of the pancreatin powder. Plain baking soda has also been advocated as adjunct in brushing the teeth and dorsum of the tongue and keeping the reaction at an alkaline pH.

Bacteriology—The mouth, according to one observer, is the "dirtiest orifice of the human body." The contrast to the relative ease with which monilia may be isolated from the vagina, the abundance and variety of resistant organisms in the oral epithelium makes isolation of the offending fungus relatively more difficult. Fungi are omnipresent here and months have reported that their milk had a bitter or "off" taste

Many patients volunteered the information that emotional strains or nervousness seemed to cause more "acidity" in the mouth and upper gastrointestinal tract The psychoneurotic factors as one of many causes of BHT are interesting, but not conclusive

METHODS OF TREATMENT AND MATERIALS

Color Photography—In the present study only the more obvious BHT patients had their tongues photographed before and after treatment One case of submandibular abscess, an extension from BHT, is presented in the color insert to this paper, and three photomicrographs of biopsy sections from the tongue

Mechanical and Chemical—At first the usual moniliciides, such as gentian violet or crystal violet, were tried as topical applications on the tongue, and then as a 1 100,000 mouth wash or gargle In the acute "thrush" phase this would be relatively effective when Nystatin® was used concurrently, but at the time of application to a yellow-brown or black tongue, it was noted that very seldom did it penetrate below the protective mucoid blanket, and as a result the condition persisted Mechanical scraping with a spoon-type curette was next tried with more success in directly reaching the tongue surface, next, a ball of gauze held with a Kelly forceps seemed to aid in removal of the slick blanket of mucus, but with all this mechanical effort the average time needed to clear up the surface of the tongue to a normal reaction and appearance was about two months, varying from two weeks to almost two years in one case Often the condition would reappear, usually after a round or two of penicillin or other antibiotics That the pioneer spirit is not yet dead is evidenced by the acumen of one patient in using the old corn cob to scrub the dorsum of the tongue, and when that began to hurt he switched to "sheeting" or burlap in six inch squares This would peel the coating and "hairs" off like the layers of an onion Lastly, the best effect could be obtained by a No 10 blade held in the Kelly forceps and shaved or scraped the specimens. Where possible stains for fungi were done in addition to the routine H&E procedure. One pathologist agreed with the diagnosis of BHT, the other deemed from the microscopic picture for simplicity's sake and consistency, that the specimen was a squamous papilloma. Chronic inflammation was present in both, in Case 7, the rete pegs were more irregular in their configuration. In the photomicrographs in the insert, the hyperkeratotic "caps" are easily seen, in spite of their somewhat tangential sectioning during processing. The "baleen" nature is seen to be due to the unshed keratinized filaments. The capture of these processes of debris and bacterial-fungal colonies is illustrated. This fundamental picture is no different than that found in the Pillsbury textbook and the "Atlas" of Arthur C. Allen. The biopsy site is generally in the midline of the posterior half of the tongue and anterior to the circumvallate papillae as the tip and edge or border of the tongue is not involved in this *biocenosis*.

Enzymes and Supportive Therapy—The pancreatin used in this study is the whole pancreas which had been defatted, completely dehydrated, and then powdered. It is about six times the U. S. P. or N. F. potency. When the patient was first seen and found to have one of the "coats" of the BHT syndrome, a pH determination was made, and usually the reaction was found on the acid side of the pH scale. A BA plate and Sabouraud plate were then planted with tongue scrapings. Next, the tongue was generously powdered with pancreatin which was allowed to remain on the tongue from five to fifteen minutes, the patient being instructed not to swallow while the powder is in the mouth. After spitting out the accumulated saliva, the affected area of the tongue was then shaved or scraped with the No. 10 blade held firmly with a Kelly curved forceps. It was found that the pancreatin had softened, and dissolved the mucoid blanket and filiform papillae involved. Lastly, the tongue was generously swabbed with a crystal violet aqueous solution, the patient was instructed how to clean his tongue at home and warned not to use the stain over five days at a time without resting several days to prevent reactions. Vigorous brushing of the dorsum of the tongue as often as practicable was advised.

appear often in normal mouth cultures, but it is in the pathogenic states induced by antibiotics that they assume medical importance

From the evidence to be presented in the case reports, the previous association of *Candida* and other fungi as well is accepted, but emphasis is on the secondary and parasitic nature of the infection The baleen nature of the keratinized filaments is again recalled, however, in three of the nine proven cases of BHT *Geotrichum* was isolated This fungus has a clinical picture, orally, almost identical with the oral lesions of *Candida*, in fact, culturing is the *only* way to differentiate between the two, as the treatment so far advocated has been very different for each [21] This is contrary to a recent editorial comment which stated “ it is quite evident that secondary infections due to fungi (particularly the monilia) are infrequent and do not constitute a serious problem with antibiotic therapy ”[22] By using the Hyland Laboratories blood agar and Sabouraud's dextrose agar in the plastic plates or petri dishes, the following micro-organisms were isolated diphtheroids, aerobic gram positive spore-forming bacilli, *Aero-bacter-Klebsiellas*, alpha streptococci, flavo-bacteria, *Cladosporium* sp , *Verticillium* sp , *Penicillium* sp , *Rhodotorula* sp , gram negative cocci and diplococci resembling pigmented *Neisseria* sp , *Candida* sp not *albicans*, *Candida albicans*, and *Geotrichum* Much of the color, therefore, could come from the various color formers here mentioned, in addition to decaying food particles, tobacco stains and other food colors, *e g* , licorice, blackberries, nuts, paregoric and iron compounds

In order to be certain that, in taking cultures from patients, room contaminants were not grown and identified as coming from the tongue, several blood agar and Sabouraud's plates were exposed for 24 hours in the main treatment rooms, then placed in the incubator All fungi grown were identified as non-pathogenic non-spore formers Cultures were, at the same time, taken from normal appearing mouths and tongues, but no fungi were grown An occasional yeast, not *Candida*, was isolated, as were normal mouth organisms

Pathology—The Martin core hand drill was used to obtain

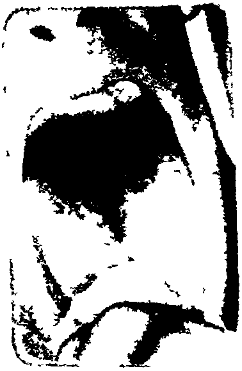


Fig 1 The tongue of case 1 which had persisted for two and one-half years showing BHT

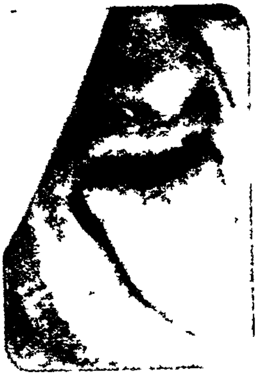


Fig 2 Same tongue as in Fig 1 showing result after one week of pancreatin powder and vigorous scrubbing with toothbrush

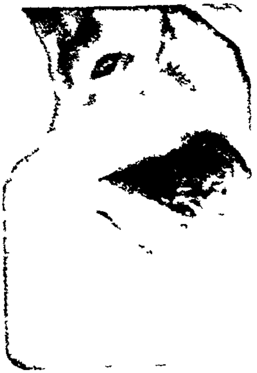


Fig 3 Tongue of Case 2 showing the mossy appearance

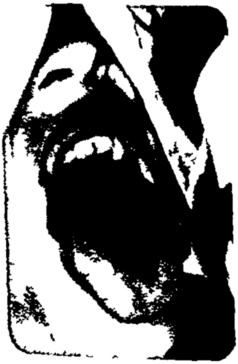


Fig 4 *Aspergillus* was one of several fungi isolated in Case 3

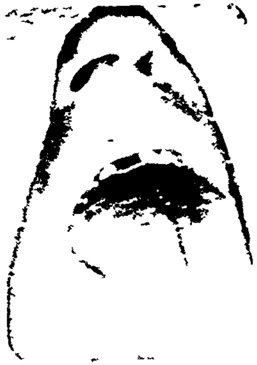


Fig 5 Tongue of Case 4 from which *Geotrichum* was isolated

Fig 6a Biopsy section of Case 4 (low power) showing clumps of bacteria and debris Filiform hyperkeratosis is well illustrated

Fig 6b Higher power of section of hyperkeratotic epithelium The accumulation of debris in the crypts favors growth of resistant organisms and the various fungi, these cannot be reached by ordinary solutions, but pancreatin being a keratolytic, enables various surface tension lowering agents to reach the source of the *biocenologic* growth

Several patients volunteered the information that the taste of pancreatic powder, while not too pleasant and of a strong "musky" scent, was nevertheless much more palatable than Nystatin ®

CASE REPORTS

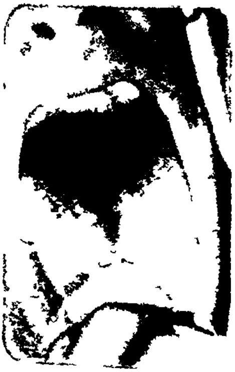
1 Mr R G B was a 45 year old carpenter, who sustained a basal skull fracture without loss of consciousness when he fell backwards from a six foot ladder While being treated in the hospital for a fracture through the right temporal bone involving the bony external canal, he developed BHT from extensive penicillin prophylaxis A multitude of various products were tried, starting with gentian violet locally, and almost daily scraping with the large ethmoid curette At times, in despair, he would consult with another physician, who prescribed antibiotic troches, which made the condition worse He noted that after eating frozen chicken the condition which had almost cleared, would again become as extensive as formerly (see Fig 1) A foul odor and taste was noted by the patient The pH of the tongue was 5

Several cultures of the tongue scrapings were necessary to isolate yeasts and fungi *Cladosporium* and *Verticillium*, which at first was thought to be *Geotrichum* Quite by chance he recently had several infected teeth removed by his dentist, and gum treatment for the remaining the BHT persisted Then on the advice of his dentist as a tartar control measure, he started using a proprietary tooth powder containing papain, and in one week the tongue lesion had disappeared When he did not use the powder the coating returned, so he was put on Pancreatin powder charts three times a day and instructed to brush the tongue vigorously after 15 minutes Since then the pH has remained neutral or slightly alkaline and the tongue remains clean (see Fig 2) He also was placed on Entozyme® tablets t i d, Allbee with C® capsules p c, and remains free of coating at the present writing

2 Mr R T, a 76 year old retired farmer, was routinely examined for epistaxis and found to have Rendu Osler's disease In addition the tongue was "mossy" (see Fig 3), and he recalled after a few minutes having a series of penicillin shots for a "cold" about two years previously, but stated that he was in no discomfort He refused biopsy and treatment but did permit culture of tongue scrapings This grew out no fungi, but did reveal numerous yeasts, not *Candida*, micrococci, alpha streptococci diphtheroids and unidentified pigmented gram positive rods

3 Mrs P C was a 48 year old accident prone housewife with numerous complaints, who had received the gamut of antibiotics and sulfas for various auto accidents and a recent accidental bullet wound of the forehead The missile grazed the skin and bone while she was cleaning a 22 caliber pistol When she came in complaining of a sore throat, and wanting more penicillin for control, examination of the tongue revealed BHT (see Fig 4) Cultures of the tongue showed non hemolytic streptococci and diphtheroids There were a variety of fungi present *Cladosporium*, yeast, not *Candida*, and one colony of *Aspergillus* She has done well on pancreatin and supportive vitamins The tongue remains free of coating

4 Mr R T, a 45 year old chicken farmer from North Georgia was the most interesting and conscientious of all the patients He recalled having a series of penicillin shots for a cold approximately four years prior to examination (see Fig 5) During the interim he carried out his usual duties with his chicken farm which involved dumping 500 lbs of an



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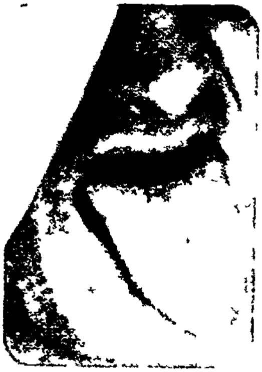


Fig 2 Same tongue as in Fig 1 showing result after one week of pancreatin powder and vigorous scrubbing with toothbrush

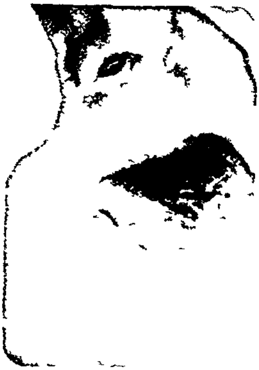
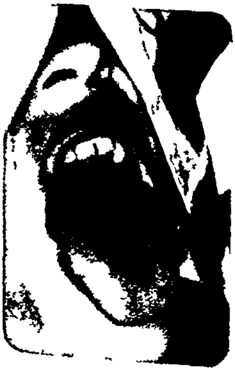


Fig 3 Tongue of Case 2 showing the mossy appearance



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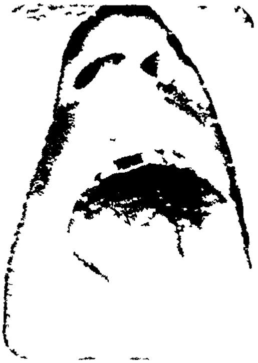

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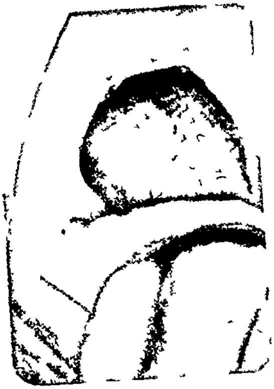

Fig 7 Tongue of Case 5 *Geotrichum* isolated from scrapings Black hairs are in mid line posteriorly

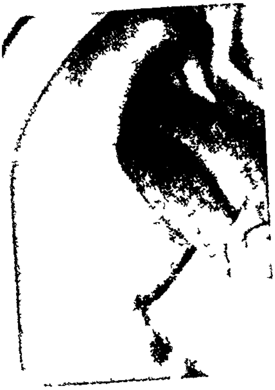

Fig 8 The yellow brown of case 6 *Geotrichum* was isolated

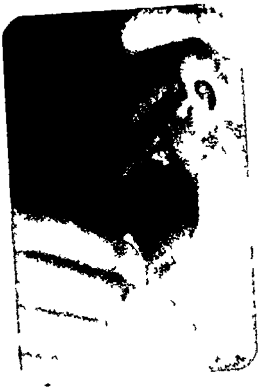

Fig 9 BHT that had persisted in Case 7 for at least six months She was unable to protrude the tongue any farther, (See Fig 10)

Fig 10 Same Case 7 showing left submandibular swelling in addition to fatty tissue normally present in this obese individual

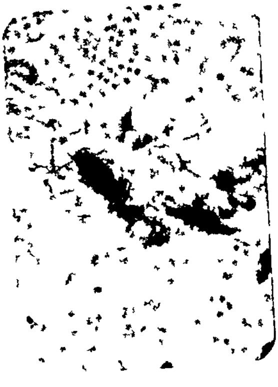

Fig 11 Biopsy of tongue in Case 7 (oil immersion) showing clusters of small bodies which could not be distinguished from certain fungi Her coating had disappeared in ten days

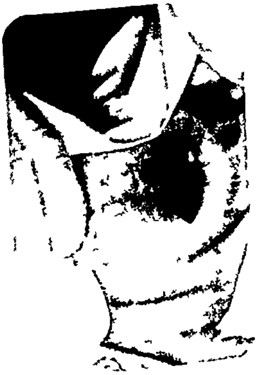

Fig 12 BHT of Case 8 A yeast and a *Cladosporium* sp was isolated from tongue scrapings The uveitis did not clear up until the tongue lesion was under control

Fig 13 Case 9 This was the most markedly black tongue of the series A *Candida* sp not albicans was isolated from the scrapings He refused treatment and biopsy

antibiotic feed at suitable intervals into the feeding troughs Each time he would be engulfed in a cloud of feed dust and antibiotic powder It is presumed that this was the cause of his BHT, constant daily exposure to small quantities of tetracycline and other antibiotics Instead of buying an expensive tongue scraper at the local surgical house he hit on the idea of using the old fashioned corn cob This proved most helpful in cleaning the dorsum of the tongue, and when it became too raw, he switched to burlap or "sheeting" cut into 6-inch squares This would enable him to peel the coating off like the layers of an onion This procedure would fairly well control the lesion but when within the past month, pancreatin powder was advocated, his tongue cleared within one week Cultures of the tongue showed *Geotrichum* He consented to a biopsy of the tongue (see Fig 6)

5 Mr W B, a 77-year-old business man, came in with a "bad cold" of many months duration Examination revealed an allergic rhinitis and BHT see Fig 7) He gave a history of antibiotics eight months prior for the beginning of this "cold" Tongue cultures revealed *Geotrichum* He has cleared up within ten days of supportive vitamins Allbee with C ® Entozyme ® and Dimetane ® for control of his rhinitis He denied prior history of hay fever, and nasal smear showed up over 50 per cent eosinophiles

6 Mr B.A, a 24-year-old druggist, had received a series of antibiotics for an acute upper respiratory infection about six months prior to examination During the ensuing months he noted a foul taste in his mouth and a constant "nagging' ache in his throat The tongue was coated (see Fig 8) and in less than a week treatment with pancreatin powder t i d on the tongue for 15 minutes the lesion was gone and the tongue was normal *Geotrichum* was isolated in cultures Reaction of the mouth saliva was pH 5 prior to therapy and when the tongue had returned to normal reaction was neutral He remains well with supportive B complex vitamins and occasional use of pancreatin powder

7 Mrs M P, a 34-year-old nursemaid began noting an intermittent left submaxillary swelling following eating and a very 'bad taste" to her mouth She consulted several physicians who prescribed various antibiotics but with no alleviation of her complaints When she was seen in the office on August 8, 1958 she had a hard tender mass in the submental region and point tenderness in and around the left submaxillary gland (see Figs 9, 10) The tongue was definitely BHT There was marked trismus, odyn and dysphagia The sublingual swelling limited her speech and nourishment was chiefly liquids Oral temperature was 102° F She was accordingly admitted to the hospital with a tentative diagnosis of Vincent's angina secondary to abscess of the left submaxillary gland and BHT Smear from the mouth did not reveal any fuso-spirochetal organisms and culture eventually grew out a hemolytic staphylococcus aureus No fungi were noted A biopsy was advised and agreed to (see Fig 11) She was given daily I M. one gram of Kanamycin for six days and hourly hot saline irrigations sublingually and externally to the submandibular region On the sixth hospital day the left submaxillary duct was catheterized after oral and external X-rays failed to show a salivary stone, and 0 3 cc of iodized oil injected into Wharton s duct. The X rays revealed a normal sialogram without any dilatation of the smaller ducts in the gland itself X rays of her teeth were negative The tissue surrounding the duct was thickened and eventually with all her treatment the abscess opened just below the papilla of the orifice, and discharged about a cupful of foul-tasting pus The best interpretation of the facts seems to be that the left submaxillary gland was not involved but the surrounding lingual tissue was secondarily involved from the infestation of her tongue The pH during the period of BHT was 5 after instituting pancreatin powder method and vigorous brushing of the tongue and

scraping with the No 10 blade, pH was neutral, and since recovery of normal tongue appearance, pH has remained neutral

8 Mr E D L, a 54-year old street sweeper was seen the fourth day after a severe injury to the left eye, caused by a tree branch being deflected by *the windshield of the sweeper striking a deep gash in the cornea* He had been treated by another physician for the previous four days with antibiotics but no mydriatics A widespread ulceration of his cornea was found, associated with a traumatic iritis *Aerobacter* sp sensitive only to chloramphenicol was cultured from the ulcer He was responding poorly to standard treatment and was hospitalized for I V typhoid therapy During this admission it was discovered that he had BHT (see Fig 12), which grew out a yeast and a *Cladosporium* sp Pancreatic powder therapy was then instituted and his vitamin intake increased It was noted that his ocular disease did not improve until the tongue lesion was under control

9 Mr M L P, an 81-year old semi invalid with "back trouble," was seen because of deafness and tinnitus He gave a history of having chewed tobacco for almost "all my life" About two years ago he had received a series of penicillin and "mycin" injections for a "cold" For a long period prior to examination he noted a "bad taste" in his mouth The tongue presented the appearance (see Fig 13) dorsally of caracul, or black lamb's wool, from the foramen caecum to the tip, the appearance more like that of a two toned automobile, being black on top and pink along the sides The pH was 5 and cultures revealed *Candida* sp but not *Albicans* He refused biopsy and only reluctantly accepted an alkalinizing regime for his tongue lesion

DISCUSSION AND ANALYSIS OF 127 CASES OF "COATED TONGUE"

Every one of the cases could give the history at some time or another, varying from four years to the past few weeks, of having had one or several of the antibiotics, including most frequently the broad spectrums prior to examination Many patients who complained bitterly of a mild sore throat or a constant ache best located in the hypopharynx, came into the office requesting "*just a shot of penicillin*" to clear up the symptoms Needless to say, very few even got the antibiotic most sensitive to the actual infecting organism on the tongue, and then only when a serious complication such as submandibular abscess or laryngeal edema ensued

Though only nine cases could be ascribed to BHT, there were 42 which could be classified as light yellow to brown, and 76 that were white The BHT people had very few complaints, but when they did, the extensions were more severe than in the other groups These extensions or concomitant disease manifestations were present in five cases out of the 127 One had an accompanying sub-lingual abscess *not* involving the teeth or sub-maxillary gland, one had acute edema of the right arytenoid almost completely closing the glottis and responding well to ACTH and Mediol®, a third had bilateral vocal cord edema with hoarseness as a result of the constant clearing of the throat initiated by the presence of the cenosis at the base of the tongue and a feeling of a "lump in the throat", a fourth (see Case 8) had a severe corneal ulcer, from which *Aerobacter* sensitive only to chloromycetin was isolated, and a uveitis which responded to the usual heroic measures only after his BHT was under control, and the fifth had a mild uveitis responding to typhoid therapy and mydriasis only after his lingual cenosis was cleaned up

Practically all patients had one or more manifestations of allergy involving the nose, throat or conjunctivae They are apparently *allergic to their own organisms* The white tongues most frequently had a yeast, not *Candida*, and many of the yellow-brown ones grew out one or more flavo-organisms, and usually just one significantly resistant organism Smears were taken in all patients, and not one had Vincent's fusospirochetal organisms present When a purulent sinusitis appeared in several cases, it was treated with aeration and drainage and the appropriate antibiotic, while covering the patient with vitamins and anti-fungal agents Even then these developed more of coating to the tongue which did not clear up until the antibiotic was discontinued

In addition to the allergic rhinitis symptoms that practically all patients manifested, other E N T complaints involved external otitis, from which monilia and other resistant organisms were cultured in 15 cases Referred pain either to the back of the neck, referred to the ear or anteriorly toward the thyroid region, was noted in 34 patients

Concomitant symptoms in other parts of the body ranged from vaginitis in nine women, pruritus ani and cystitis of equal incidence in each sex, 23 males and 25 females Other diseases included diabetes in two cases, either uveitis or corneal ulcer, or both, in two cases, duodenal ulcer, submandibular abscess, and laryngeal (arytenoid) edema, glottic trauma resulting in vocal cord edema and hoarseness, one each.

In the 127 cases reviewed there were about 5 per cent failures in response to treatment Those cases in which the initial pH was found to be 5, tended to require a longer period for resolution of the lingual cenosis than those in which the pH was 6 or greater Those that failed to clear up were those who did not conscientiously follow the regime outlined for them, or those who in spite of warnings persisted in obtaining "shots" of antibiotics for minor upper respiratory infections It is to be emphasized again that persistence both on the part of the physician as well as that of the patient is necessary in order to obtain completely satisfying results

SUMMARY

Black hairy tongue is not an isolated disease involving the tongue alone, it is actually a syndrome of the head and neck, with occasional manifestations in the genito-urinary, gastro-intestinal, central nervous system, and with often serious local extensions The various stages in its development can be unified by the concepts both of *micro-* and *macro*-biocenosis The heretofore multiple compartments into which the "coated" tongues were divided, frequently caused hair tearing exasperation so that the physician often found himself treating a concept rather than the disease or the patient, can now largely be discarded Rational treatment and management can be based on physiologic and cenologic principles which greatly simplify the matter Involved in the syndrome of BHT are

1 It is practically always initiated by the antibiotics which suppress sensitive micro-organisms, allowing the various resistant bacilli, cocci, and fungi to develop their own micro-biocenologic relations in the feathery filimentary papillae of the tongue dorsum The tip and sides of the tongue are not involved This parasitism is secondary and not primary, nevertheless, it causes more or less distress to the patient, depending on his resistance and the state of his immunity The titer of these last two factors determines its manifestations, whether "thrush" in those with weak constitutions, or a "coated" tongue that varies from white, through yellow-brown, to black hairy or "mossy" tongue in those of stronger resistance The oral acidity probably determined by aciduric micro-organisms tends to perpetuate this state of cenosis by preventing the normal attrition of the keratinized filiform papillae The organisms aid in this by forming a mucous blanket, which prevents medication from reaching the source of infection To maintain the nutritional status of the individual, B complex with vitamin C and sometimes large doses of oral vitamin A are essential

2 *Allergic reactions* to one's own micro-organisms located on the tongue These vary from mild nasal stuffiness to the full-blown typical allergic rhinitis, and even purulent sinusitis in patients who have never before experienced "hay fever " The conjunctivae and lids may also be involved, as can the external auditory canals Frequently there is a moniliasis of the external canal concomitant with the same type of infestation of the tongue Many patients complain of a "dry" throat, or an irritation of the throat at the level of the cenosis, with a constant desire to clear the throat Parabromdylamine maleate has been found far superior to any other antihistamine in treating these complaints The corticosteroids, while effective in controlling the allergic state, also favor spread of fungi

3 The concept of a *parasitic cenosis* is sustained, but emphasis must be on its secondary nature A multitude of resistant organisms can be found, both as to variety as well as to quantitative numbers, but more significantly in three cases *Geotrichum* has been isolated Its clinical similarity to *Candida* is noted, and only by cultural studies can it be differentiated This is important because treatment of the two is different, iodides for the former, gentian violet for the latter Out of the series of 127 cases, *Candida albicans* was isolated from the tongue in only two cases

4 Although all 127 cases studied gave a history of antibiotics at some time during their period of symptoms prior to diagnosis, not one case was found associated with malignancy, and only two had diabetes One case acquired a duodenal ulcer while awaiting the outcome of his compensation case One case was presented with associated submandibular abscess by a resistant staphylococcus An autogenous vaccine was considered, but with rapid recovery of the pa-

tient was not advised. Another case was noted with acute laryngeal edema involving the arytenoid on the right, a yeast, not *Candida,* and *Aerobacter* was isolated from his tongue. One case had bilateral vocal cord edema from constantly clearing her throat. The cenosis at the base of the tongue gave her the sensation of a "lump" or something that would neither go up nor down. Two other cases had an associated eye involvement which did not begin to heal until their tongue lesions had cleared. Most of the individuals noted a fetid or "bad" taste in the mouth. They came in complaining most frequently of a sore throat, and not a few wanted more penicillin. Many of the women complained of aches and sharp pains radiating to the back of the neck and down anteriorly toward the thyroid area. Apparently all of the patients had a lowered resistance to a recent infection, bacterial as well as viral, and most had received one or more "shots" of penicillin. Not a few had pruritus, and some women stated that they had a prolonged course of treatment for vaginitis during the time of their "coated" tongue. The public health aspects of this problem will become more important in the future, as more of our population are exposed to "hidden antibiotics" in our food, and particularly milk products, these factors probably account for many of the cases presented here, and may lead directly to a recurrence of the BHT when the patient is exposed to even minute amounts of penicillin, for example, in milk.

To break the protective blanket laid down by the resistant organisms, mechanical scraping with cup or spoon curette and other novel instruments has been utilized. Emphasis is placed on persistence by both patient and physician. Purified pancreatin in powder form, held on the tongue for periods up to 15 minutes, has been found most useful in preparing lysis of the keratinized filiform papillae. It is much less toxic than podophyllin. Prior to using pancreatin in treatment, the average time for clearing the tongue was about two months. With pancreatin the restoration to normal required a much shorter time, averaging about a week or ten days.

The pH of the oral secretions can easily be determined by using paper strips specially prepared and indicator chart In BHT it is found to be markedly acid, up to pH 5, while normal mouths are slightly acid to neutral During and immediately after using pancreatin powder the reaction is alkaline

In closing, it would be appropriate to quote some of the conclusions of Makower (p 782) “The knowledge of biocenology can add new weapons in the fight against infectious disease In furtherance of this aim it will be necessary, *1* to influence the humoral and the cellular environment of the parasites inside the animal body (through such factors as pH, hormones, nutritional adjustment, and vaccination) , *3* to influence microbes that may cause disease by appropriate antifungal and microbial therapy (on microbes that have become antibiotic-resistant and have established normal microcenotic relationships) , *4* to influence the establishment of solid immunity in patients treated with antibiotics by simultaneous or subsequent immunization with killed or live vaccines consisting of the appropriate microbes ”

Yes, the Greeks had a word for it *biocenosis*, and the concept will be of increasing importance in the medicine of the future

Acknowledgments The opinions expressed in this paper are solely the author's own and he alone is responsible for them, however, I express my thanks to Dr William R Bond, of the Medical Department, and Mr F Burton Hazlerigs, hospital representative of the A H Robins Company, Inc , for expediting the materials, particularly pancreatin, the vitamins and the antihistamine used in this study, also to Miss A Brim, of the Georgia State Public Health Department, and to Dr L Ajello of the C D C in Atlanta, Ga , for help in the cultures, particularly the identifications, and to Dr John Godwin and Dr James F Olley for the pathology descriptions, the latter for taking the photomicrographs in color film Last but not least, to Mrs Nora Brown, of Crawford W Long Hospital Bacteriology Laboratory, for much of the culture studies

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CLINICAL EVALUATION OF PARABROMDYLAMINE MALEATE (DIMETANE®)[*] IN ALLERGIC AND VASOMOTOR RHINITIS

J THOMAS EDMONDS, M D ,[†]

Accomac, Va

A large portion of the office practice of any otolaryngologist consists of patients with allergic or vasomotor rhinitis The otolaryngologist and the allergist cannot always differentiate these two varieties of rhinitis A number of observers have attempted to differentiate the two, and others have put them in one general category Nasal obstruction of some degree is usually present in all of these patients and frequently associated with one or more related symptoms The presence of inflammation and hyperemia or pallor, ischemia, and edema of the mucosa of the nasal passages seems to be the common denominator in this large group of patients, whether the cause is allergic, inflammatory, or related to emotional or other causes

Antihistaminics have been used in the treatment of varieties of rhinitis with good results by a number of observers This, under some circumstances, has led to the belief that those patients who benefit from the use of antihistaminic drugs have an allergic manifestation It should be noted, however, that while these drugs may overcome the effects of exogenously administered histamine and apparently counteract the effects of endogenously released histamine-like agents, they have other pharmacological effects One of these may be more specifically related to the reduction of edema of nasal mucosa

Halpern[1] has expressed the belief that the primary action of antihistaminics may be that of reducing the permeability

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[*] The parabromdylamine maleate was supplied as Dimetane® by the A H Robins Co Inc Richmond Va.

[†] The opinions or assertions contained herein are those of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large

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of the capillary wall He found that an antihistaminic agent prevented albuminuria seen under certain conditions in rabbits—a phenomena thought to be unlikely as a result of histamine We wonder if the reduction of edema could not be due to the ability of an antihistaminic agent to decrease capillary permeability in the nasal mucosa

We have observed 171 cases of allergic and/or vasomotor rhinitis in recent months and have followed their response to treatment with the antihistaminic agent, parabromdylamine maleate (Robins[2,3,4,5]) In the classification of response to treatment a definite positive response was considered in those patients who reported their symptoms satisfactorily controlled or asymptomatic as a result of therapy

MATERIAL

More than 200 patients were seen in the outpatient clinic of the U S Naval Hospital, Newport, R I, and 171 of these patients were followed for periods up to six or more months Parabromdylamine was employed in all of them for the relief of their symptoms related to allergic and/or vasomotor rhinitis The chief complaints of these patients were

1 Nasal obstruction
2 Post-nasal drainage
3 Loss of hearing
4 Sinus-like pain
5 Cough

The group consisted of 112 adults and 59 children, and nasal obstruction was present in each case and frequently associated with other symptoms Females outnumbered the males 112 to 59, and adults outnumbered the children 112 to 59 Patients were followed at frequent intervals and a six-month or greater follow-up after improvement was made in all of the 171 cases reported

ASSOCIATED CONDITIONS

Eustachian salpingitis with definite hearing loss was noted in 62 patients Treatment in these patients consisted of intranasal Eustachian tube catheterization followed by parabromdylamine [Dimetane Extentabs twice a day employed in 50 adults and Dimetane tablets (4 mg) or Elixir in 10 children] On this therapy, 46 of the 50 adults improved satisfactorily with but one inflation of the Eustachian tube It was noted by most of the patients that if the antihistamine was stopped before one week of therapy the symptoms tended to recur Where this was reported their symptoms were again controlled by the use of parabromdylamine Eight of the adult women with Eustachian salpingitis were pregnant All of them reported satisfactory response from their original episode, and six of them had a recurrence later in pregnancy which was again relieved with same treatment

TABLE I

171 Patients with Symptoms Related to Allergic or Vasomotor Rhinitis

Specific Symptoms		Results with Dimetane®	
Eustachian salpingitis	62	Apparently cured (no recurrence in 6 months)	59
Post nasal drainage	97	Improved	89
Cough	41	Failed to respond	23
Sinus pain	50	Patients preferring Dimetane to other antihistaminics	97
Laryngitis	4	Patients preferring other antihistaminics to Dimetane	5
		Patients who continued to use Dimetane p r n	73
Adult patients			112
Pediatric patients			59
Males			59
Females			112

Post-nasal drainage and nasal obstruction was noted in 97 patients Fifty-five of the 62 patients with this complaint had a significant decrease in their symptoms on treatment Thirty-three of the 35 pediatric cases noted a definite decrease in both the anterior and posterior nasal drainage under treatment Some patients reported that their nasal secretions became thicker while on the antihistamine, but this was never severe enough to discontinue using the drug

Cough and nasal obstruction which had not responded to the usual cough remedies was present in 41 patients Thirty-six of the group improved while taking parabromdylamine but noted a recurrence of cough if the treatment was stopped in under two weeks' time Many of these patients continued to use the drug as necessary with gradual complete relief of symptoms in all but one case

Sinus-like pain with nasal obstruction showed quite rapid response to the drug Pain was noted in various combinations in maxillary, frontal and ethmoid sinus regions, and for the most part was relieved to a significant degree in 24 hours Forty-eight cases showed complete relief of symptoms within seven days, but two cases noted no improvement Several of these cases had actual fluid levels on roentgenogram, but, adequate spontaneous drainage occurred with *elimination* of mechanical blockage These sinuses cleared without the use of antibiotics or antral irrigations

Five patients had marked nasal obstruction due to chemical rhinitis from prolonged indiscriminate use of nose drops On parabromdylamine, these patients showed improvement within 72 hours of stoppage of local nasal medication, and continued clinical improvement was marked within two weeks' time All of them had been using nose drops for many months and showed no relief of nasal obstruction with other antihistaminics employed

COMPARISON WITH OTHER ANTIHISTAMINICS

Of this group of patients, 97 of the 171 cases found Dimetane® better than any other previously employed antihistaminics Seventy-three cases continued to use Dimetane® as neccessary with relief of recurrent symptoms Forty-eight cases had not used other antihistaminics as far as could be determined Five patients noted better relief with other antihistaminics than with Dimetane ®

SIDE EFFECTS

Thirteen patients had side effects of significance Five complained of being drowsy although only one was drowsy to such a degree that treatment had to be stopped One complained of palpitation and another of severe dryness of the throat Both of these patients discontinued treatment because of these complaints

Seven children were treated with Dimetane Elixir over a period of four to six weeks All noted a marked decrease in symptoms the first week, later, four became refractory to the drug, and symptoms returned while they were still using the agent This was not reported with the tablets or the Extentabs

Dimetane tablets, 4 mg four times a day, did not seem to be as satisfactory as the Dimetane Extentabs, 12 mg twice a day The Extentabs usually were effective for 8 to 12 hours Several patients used an extra 4 mg tablet to supplement the Dimetane Extentabs medications

DISCUSSION

The fact that 87 per cent of this series of patients had beneficial results from the use of the antihistamine parabromdylamine maleate, does not establish the fact that their symptoms were of an allergic nature, nor does it establish the fact that histamine-like substances are responsible for the induration or edema of the mucosa of the nasal passages It is interesting to speculate upon the concept presented by Halpern that the primary action of antihistaminic agents is in reducing the permeability of the capillary wall The decrease of local tissue edema of nasal mucosa may be due to this type of action by parabromdylamine maleate

The findings of Thomas[2] are confirmed in that those patients who had multiple manifestations of allergy showed a higher percentage of response to therapy than those who had a single manifestation In our experience Dimetane® was of little value in the treatment of the routine common cold

CONCLUSION

Eighty-seven per cent of the series of 171 patients with allergic and vasomotor rhinitis and related symptoms were relieved by the antihistaminic, parabromdylamine maleate Thirteen per cent reported no improvement Minor side effects occurred in 13 patients or 7 6 per cent Dimetane Extentabs 12 mg appeared to be more effective than Dimetane under two weeks' time Many of these patients continued to use the drug as necessary with gradual complete relief of symptoms in all but one case

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AMERICAN ASSOCIATION FOR CLEFT PALATE REHABILITATION

The American Association for Cleft Palate Rehabilitation will hold its Eighteenth Annual Convention at the Brown Palace Hotel, Denver, Colo , Thursday, Friday and Saturday, May 12, 13 and 14, 1960

This Association is composed of medical, dental and paramedical specialists who are interested in the rehabilitation of persons with cleft lips and palates

ANTIHISTAMINIC THERAPY

FRENCH K. HANSEL, M.D.,
St. Louis, Mo.

HISTAMINE

It is generally believed that histamine is produced or released in the tissues as the result of allergic reactions, trauma, infection, fever, stress, physical agents and emotions.[1] Patients with allergic manifestations appear to have a diminished tolerance to histamine. It is known, for example, that in such patients small amounts of histamine will precipitate an attack of bronchial asthma. Dragstedt and Mead[2] demonstrated an increase in the histamine level of blood and lymph of dogs after anaphylactic shock. The amount demonstrated was sufficient to account for the reaction. Similar studies have been reported by Code[3] who used guinea pigs rather than dogs.

HISTORY OF ANTIHISTAMINES

Because of the important relationship of histamine to the allergic reaction, many attempts have been made to counteract or to antagonize the effects of histamine in the body. The first successful use of an antihistamine was reported by Fourneau and Bovet[4] in 1933; however, the phenolic ethers with which they were working proved to be too toxic for general use. Later, compounds containing the ethylenediamine radical were developed which were satisfactory. Quite a variety of antihistamines are now available, most of them belong to one of the three chemical groups.[5]

CHEMISTRY

The three groups are ethylenediamine derivatives, ethanolamine derivatives, and monamines. Examples, identified by trademark, are the following:

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Ethylenediamine derivatives Antergan, Chlorothen, Diatrin, Histadyl, Neo-Antergan, Neohetramine, Phenergan, Pyribenzamine, Pyrrolazote, Tagathen, Thenfadil, Thenylene

Ethanolamine derivatives Benadryl and Decapryn

Monamines Chlor-Trimeton and Trimeton

In addition, there are a few other antihistaminic agents which are unrelated chemically to the three classical groups Examples of these miscellaneous compounds are Antistine, Chlorcyclizine, Di-Paralene, Perazil and Thephorin

RESPIRATORY ALLERGY

The most satisfactory response to the antihistamines has been noted in patients with seasonal hay fever Better results have been observed when pollen of trees and grasses rather than of ragweed is the causative factor, because of the lesser degree of exposure Response, therefore, is more or less proportional to the degree of exposure Secondary factors, especially other sensitivities, may play a great part in influencing the effectiveness of the drug

The response in chronic perennial nasal allergy has not been as encouraging as in hay fever The rhinorrhea is usually most modified In some cases, the dryness of the nose may be objectionable

FREQUENCY OF ADMINISTRATION AND SELECTION OF DRUG

The average duration of effectiveness of most antihistamines is about four hours Because of drowsiness as a side effect of some of the more potent agents, ambulatory patients in the past have usually been treated with repeated doses of drugs in the ethylenediamine group or with small doses of one of the ethanolamine derivatives The recent development of a triple antihistamine, containing one representative compound from each of the three groups in a special base from which a constant amount of medication is liberated over a period of eight hours, may simplify not only the dosage schedule but also the selection of the agent The new preparation is known by the trademark, "Tridecamine Dospan "*

HUMAN BIO-ASSAY

After determining that the antihistaminic agents are liberated from the base over an eight-hour period of time, Jones and his associates[6] measured the size of the wheal produced by 0 1 cc of a 1 10,000 concentration of histamine diphosphate in aqueous solution, injected intradermally in the forearm immediately before administration of Tridecamine Dospan and repeated every two hours for a period of 14 hours During the entire period of observation, the wheals were always smaller than prior to treatment in the group receiving Tridecamine Dospan Untreated subjects were used as controls In this group, the wheals not only were not smaller, they actually became larger as the series of histamine injections was repeated

CLINICAL EXPERIENCE WITH TRIDECAMINE DOSPAN

Preliminary trials with Tridecamine Dospan were begun in the hope that the compound would produce prolonged symptomatic relief in those patients capable of responding to antihistaminic therapy, and that side effects would be virtually eliminated The hope for relative freedom from side effects was based upon two theories, the first was that very few people would be sensitive to agents from more than one of the three major chemical groups Accordingly, the side effects should not be additive, although the antihistaminic or therapeutic effects would be Secondly, the gradual release of a medication to which a patient is sensitive would be less likely to produce severe side effects than would the rapid release of the same medication Indeed, this phenomenon is best illustrated in the case of nicotinic acid, which can be released from the same base, usually without producing flushing

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*Tridecamine is the trademark of The Wm S Merrell Company Cincinnati 15 O for a combination tablet containing 20 mg each of doxylamine succinate pheniramine maleate and pyrilamine maleate Dospan is the trademark of The Wm S Merrell Company for the special sustained-release base

The clinical response to Tridecamine Dospan has been highly gratifying The patients were all suffering from nasal allergy There were 92 males and 133 females, all adult The dosage varied from one tablet every eight hours to one tablet every 12 hours In most cases, only two tablets per day were required The duration of therapy varied from ten to 30 days In this group of 225 patients, there were only 15 (6 6 per cent) therapeutic failures In 30 other patients (13 2 per cent) there was only moderate symptomatic improvement In the remaining 180 patients (80 2 per cent) the symptomatic relief was excellent

Perhaps the most important reason for popularity of the new preparation among the patients was the dependable relief of nocturnal nasal symptoms Drowsiness was extremely uncommon and when it did occur, did not interfere with ordinary activity

SUMMARY AND CONCLUSIONS

Tridecamine Dospan is a new triple antihistamine from which the medication is released gradually over a period of eight hours to produce an antihistaminic effect for 12 hours or more In a series of 225 patients suffering from nasal allergy, it produced highly gratifying symptomatic relief in 80 2 per cent, moderate relief in another 13 2 per cent, and no relief in only 6 6 per cent The dose is one tablet every eight to twelve hours

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GILL MEMORIAL EYE, EAR AND THROAT HOSPITAL

The Gill Memorial Eye, Ear and Throat Hospital has just completed its Thirty-second Annual Spring Congress in Ophthalmology, Otolaryngology and allied specialties There were forty-two states, England, Canada and several foreign countries represented There were twenty-one guest speakers, sixty lectures and closed circuit televised surgery during the five and one-half days of the Congress In 1960, the Thirty-third Annual Spring Congress will be held from April 4 through April 9

ABSTRACT OF THE PROCEEDINGS OF THE EIGHTIETH ANNUAL MEETING OF THE AMERICAN LARYNGOLOGICAL ASSOCIATION

Hot Springs, Va, March 8-9, 1959

FRED W DIXON, M D,
President

SAMUEL SALINGER, M D,
Abstract Editor

OSTEOMYELITIS OF THE FRONTAL BONE

HARRY P SCHENCK, M D

The impact of the antibiotics on the incidence, course and therapy of osteomyelitis of the frontal bone was described by Dr Schenck in an analysis of 56 cases divided into three decades 1929 to 1938, 1939 to 1948, and 1949 to 1958 His tables showed a decline in the number of acute fulminating osteomyelitis cases from nine in the first period to none in the third period The offending organism in all types of cases in all three periods was most often the staphylococcus aureus with hemolytic streptococcus in second place

Emphasis is placed on adequate X-ray studies which require expert interpretation because the antibiotics result in bony changes that differ from those seen in the pre-antibiotic days These changes may be detected within five days of the onset, but the typical moth-eaten appearance of the bone, previously a constant finding, is now replaced by signs of deossification, decalcification and blurring of the outlines of the sinus

Sensitivity tests are mandatory in selection of proper antibiotics

Dr Schenck attributed some of the cases to injudicious probing of the sinus in the acute stage

As for therapy, he has found that simple drainage with primary removal of diseased tissue, and minimal removal of bone, was sufficient, as long as drainage into the nose is effected via enlargement of the duct and clearing of adjacent ethmoid cells In most cases sequestrums were permitted to remain *in situ* since subsequent X-rays showed restoration of the bone by reason of invasion of new vessels

X-ray pictures, taken at monthly intervals up to one year, reveal gradual disappearance of the translucent zones with replacement by new bone

DISCUSSION

Dr Oliver Van Alyea, while agreeing that the antibiotics have proven tremendously effective in limiting both the incidence and the gravity of osteomyelitis, nevertheless sounded a note of warning against complacency Occasionally an intracranial complication will develop in cases thought to be under control The emphasis placed on adequate drainage is fundamental but Van Alyea felt that external drainage could well be supplemented by intranasal irrigation via the frontal sinus cannula Some cases are due to inadequate or incompetent initial surgery on the sinuses as evidenced in several cases cited by the speaker

Dr Henry M Goodyear questioned Dr Schenck about the length of time the tube was left in place He thought it was stated to be as much as six months whereas Dr Schenck stated it was six weeks Dr Goodyear feels that sufficient drainage can be obtained by removing the anterior ethmoid cells avoiding traumatizing the nasofrontal duct and thus dispensing with the tube He has found that such a passageway can be maintained for many years He has employed the intransal removal of these cells even in acute cases and has never had an intracranial complication result He asked Dr Schenck whether external drainage via a tube could not be dispensed with if adequate drainage has been established intranasally

Dr W Likely Simpson also has employed intranasal drainage even in acute cases introducing a tube into the frontal sinus which is left in place for several days Dr Simpson then showed a number of slides of cases of osteomyelitis and several different surgical procedures for their management

Dr Daniel C Baker, Jr stated that his experience has been similar to that of the essayist confirming particularly the value of early external drainage of acute cases He personally has not seen a case of fulminating osteomyelitis in ten years He also has been using a tube for drainage via a large opening into the middle meatus and avoiding the nasofrontal duct A polyethylene tube is well tolerated for the six weeks period it is in place

Dr Schenck, in closing the discussion, stated that while he doesn t doubt Dr Van Alyea's skill in passing a frontal sinus catheter, he does doubt that many others possess the same degree of skill His experience

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Emphasis is placed on adequate X-ray studies which require expert interpretation because the antibiotics result in bony changes that differ from those seen in the pre-antibiotic days. These changes may be detected within five days of the onset, but the typical moth-eaten appearance of the bone, previously a constant finding, is now replaced by signs of deossification, decalcification and blurring of the outlines of the sinus.

Sensitivity tests are mandatory in selection of proper antibiotics.

DISCUSSION

Dr John Conley commented on the advantages of this technique, which is similar to a horizontal pharyngotomy and has the advantage of avoiding direct trauma to the intralaryngeal structures The management of a large cyst and the laryngocele by this procedure seems more than adequate with the help of a finger introduced into the cavity as described Dr Conley believed that the indications for this operation depend largely upon the accuracy of the diagnosis Often the question arises as to whether one was dealing with a cyst, a tumor or a laryngocele This might prove embarrassing if the mass happened to be malignant He has seen cases of the "iceberg" type where the growth was entirely submucosal, and another in which a cancer developed in a laryngocele The technique described seems quite simple The incision assures security so far as the superior laryngeal artery and nerve are concerned, the latter being important to conserve Removal of an adequate amount of cartilage affords sufficient working space Naturally, great care must be taken to avoid injury to the intralaryngeal structures He asked Dr Schall whether it might not be a good idea instead of removing two thirds of the alar cartilage, to come to the midline and swing the alar cartilage back on a muscle pedicle (the inferior constrictor) thus opening up the entire extralaryngeal space to work in

Dr Schall stated that he had borrowed the procedure from the transhyoid or intrahyoid pharyngotomy approach He agreed that there is some risk in the extra laryngeal approach insofar as the possibility of encountering a malignancy is concerned In his two tumor cases, one of 20 years standing, the other of ten years, he felt that preliminary biopsy was not urgent in view of their chronicity As for differentiating between a cyst, laryngocele or tumor by means of X rays, his radiologist Dr McMillan, has been unable to determine since they all cast approximately the same shadow He, too, has seen cases of carcinoma develop in a laryngocele which was not recognized until after the extirpated mass had been removed Dr Schall has known of Dr Orton's procedure, as well as that of Dr O'Keefe, in which the thyroid cartilage is split He missed seeing Dr Cardwell's movie on laryngocele at the San Francisco meeting and is, therefore, unable to comment on it, however, he is satisfied that the procedure he has just described was adequate and successful for the types of cases in which they were employed

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CARCINOMA OF THE NASOPHARYNX

Dr L Q Pang (By Invitation)

In presenting an analysis of 34 cases of carcinoma of the nasopharynx, Dr Pang brought out an interesting item relating to the high incidence in the Chinese who constituted 80 per cent of his series Similar findings were noted in reports from centers as far apart as New York and Formosa

The most common symptoms noted were enlarged cervical nodes, unilateral nasal obstruction, and ear symptoms Diagnosis is frequently missed because the lesion is not sought for, has been that many cases of osteomyelitis have developed following this procedure The use of an indwelling tube is certainly not original with himself, having been employed by others for many years Dr Goodyear's point with regard to removal of anterior ethmoid cells is well taken, and this usually occurs when one is fashioning the drainage channel from above with the rasp Maintenance of the duct and its bony walls is also an extremely important item His objection to going in from below via the ethmoid cells is that one fails to see the interior of the frontal sinus and to deal adequately with its pathology This is particularly important when there is a defect in the posterior wall As for drainage via the anterior wall, this is urgent in acute cases when there is pus under pressure in the sinus As for the much feared fulminating cases which are fortunately rare, there is little that can be done aside from the external trephine and antibiotics These cases in the past have been rapidly fatal

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AN EXTRA LARYNGEAL APPROACH FOR CERTAIN BENIGN LESIONS OF THE LARYNX

LEROY A SCHALL, M D

An extra laryngeal approach for the removal of certain benign lesions of the larynx was demonstrated by Dr Schall It was successfully employed in four cases a neurofibroma, a chemodectoma, an internal laryngocele and an external laryngocele

The procedure consists of an exposure of the thyroid ala via a horizontal incision, elevation of the internal perichondrium from the ala, removal of the cartilage from the midline to the oblique line, and from the superior margin down to include at least two-thirds of the cartilage and an incision through the thyro-hyoid membrane, which permits blunt dissection of the growth of a cyst If it is a laryngocele, after exposure of the fundus, it may be opened, a finger inserted into its lumen and removal accomplished by both sight and feel. A cyst may be aspirated and then removed the same as a laryngocele

Tracheotomy may be indicated preoperatively if there is some dyspnea, otherwise, it is performed at the conclusion of the operation

The advantages of this operation are adequate exposure, no intralaryngeal trauma and no intralaryngeal complications

Dr Samuel Salinger was impressed by the high incidence of this condition among the Chinese, which is apparently characteristic of the race since similar reports have emanated from as widely separated locations as New York and Formosa Not much was said about X-ray diagnosis In his experience roentgenography has not been very helpful except where the case had advanced to the stage where bony necrosis can be visualized Possibly laminography may be of some help in differentiating degrees of thickening of the soft tissues Experience has shown that early negative biopsies cannot be relied upon since in many cases the growth is subepithelial, and it may require several attempts with deeper bites to reach the tumor tissue

Dr Julius W McCall inquired as to whether there was a connection between this condition and the chewing of betel nuts

Dr Louis H Clerf being interested in cytological diagnosis suggested placing the patient in the posture as for a Proetz treatment instilling a saline solution and then drawing it off for a Papanicolaou stain

Dr Eugene S Hoff stated that he and the late Dr Morrison had taken a number of smears from the nasopharynx for Papanicolaou staining and had obtained positive diagnosis in some cases In line with what Dr Salinger said, in the San Francisco area Dr Hoff had noted an incidence of five times among the Chinese as compared with the Caucasian

Dr Robert E Priest whose community is predominantly Nordic, found the Chinese component practically negligible The incidence among the Nordics was found to be only one in 386,000 admissions The one case he saw was treated by implantation of radon seeds with a total dosage of 4000 *r* Subsequently an additional 3000 *r* was given by the same method and the patient is alive and well after ten years A review of the biopsies confirmed the original diagnosis of the malignancy

Dr Pang explained that the fenestration of the palate as an approach to the involved area was very satisfactory It is particularly so for cases that come from a distance and must be followed up by their local doctor The fenestra makes it possible for the general practitioner or even the patient himself to see the operated area The one case of radionecrosis of the brain had received deep X-ray thrapy to the cervical nodes followed later by treatment with the 1 000 000 volt machine at the University of California His experience with cobalt therapy which is limited, makes him feel that it will supplant deep X rays As far as betel nut chewing is concerned none of his patients had the habit to his knowledge He has tried cytologic examination of smears, and feels that it has great promise As for the radon seed therapy, Dr Pang feels that with the palate fenestra it is possible to apply more accurately any therapy you choose and certainly radon seeds can be implanted much more accurately by this method

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THE SIMULATED LARYNX

C J CAMPBELL, M D,
and
JOHN A MURTAGH, M D

Dr Campbell and Dr Murtagh reported the results of their investigations with the Gooch tube in the production of simu-

and frequently excapes notice despite nasopharyngeal examination Biopsies are often inadequate and have to be repeated until the true nature of the lesion is disclosed Pang has found the average time from onset of symptoms to positive diagnosis averaged six-and-one-half months

The lesions which are mostly transitional cell carcinomas are quite radiosensitive, yet their curability leaves much to be desired The author favors the transpalatal approach for visualization of the area and the direct application of surgical diathermy His results have not been too favorable, since remissions after primary abatement have been very frequent Only six cases survived five years, two of these having already had a remission, leaving only four cases reaching a six year survival without symptoms (12 per cent) As for neck dissection, Pang feels that it is indicated only in cases where the primary lesion is definitely controlled by irradiation

DISCUSSION

Dr Daniel S Cunning commented on the fact that the diagnosis and therapy of this condition have changed very little in the past 25 or 30 years We are still baffled by the delays encountered in establishing a diagnosis, a fact which is borne out by Dr Pang's statement which revealed an average lapse of six months from the onset of symptoms While it is true that in the beginning the patient himself is at fault in failing to seek advice when the early symptoms manifest themselves, in the main the chief responsibility lies with the physician who first sees the patient, and the laryngologist whose examination of the nasopharynx is perfunctory An isolated cervical node or unilateral ear symptoms should at once alert the surgeon and should always arouse suspicion of a primary lesion in the nasopharynx While the percentage of five year cures is pathetically low experience has shown that the cases diagnosed early have at least a 50 50 chance for recovery The high incidence in Orientals is more than an incident More research along anthropological, dietary and hormonal lines is necessary to explain adequately this unusual predisposition The treatment of cervical metastases depends upon the type of growth, the more radio sensitive tumors being amenable to irradiation, whereas the more adult types require radical neck dissection The palatine approach described by Dr Pang is very useful in the visualization of the area but needs evaluation through the observations of many surgeons in this field Other points that can bear stressing are the importance of repeated biopsies if the initial effort is fruitless, and the need for disregarding psychoneurosis as a diagnosis for symptoms not yet fully explained in the beginnig

Dr Daniel C Baker asked for more information about the patient who suffered a radio necrosis of the brain During the past year he himself had had a patient with a lymphosarcoma of the nasopharynx who had been treated with cobalt and had obtained a good primary result, however, about three months later, he collapsed on the golf course with a sudden attack of vertigo lapsed into coma and expired within 24 hours Autopsy revealed a radio necrosis of the brain The case was the third of its kind reported at the New York Neurological Institute irradiation presented fewer difficulties than those which were operated at later periods In the latter, the dissection was more difficult and the frequent postoperative pharyngostomas necessitating plastic closures by flaps, etc, attested to the devitalizing effects of the irradiation

The indications for surgery in the arrested cases were general debility, dysphagia, edema and induration and frequently evidences of thyroid necrosis Healing in these cases was delayed and fistulas frequent

Of the 22 patients comprising all three groups, 15 are living and well for periods of five months to nine years Three cases died of other causes one to three years following surgery, while the remaining four died of cancer

It was noted that cases operated soon after irradiation continued to manifest the late changes due to the irradiation, such as atrophy of the skin and the appearance of telangiectases

DISCUSSION

Dr Stanton A Friedberg demonstrated the effects of irradiation with a series of slides showing particularly the endothelial proliferation in the blood vessels with eventual obliteration and the fibrosis of the supporting tissue Since these changes are slow in developing, it probably accounts for the comparative ease in dissection of the cases operated early and the complications following surgery at a later date Dr Work's results justify the rationale of undertaking surgery in all cases where prior irradiation has been unsuccessful even when attended by local complications

Dr LeRoy A Schall stated that his experience with post irradiation surgery has been contrary to that of the essayists in fact in many cases it was disastrous He showed a number of slides depicting the bad results in several cases that had been previously irradiated the surgical wounds failing to heal after break down of the tissues While it is true that in a few cases one may get by it is still a matter not to be taken lightly, because the breaking down of the operative field with all that it entails leads to demoralization of the patient dissipation of life savings and a period of frightful suffering before the end

Dr Paul H Holinger pointed out the importance of visualizing the possible reparative and reconstructive measures that may have to be employed postoperatively It might be wise therefore to anticipate such measures and to do some preliminary reconstruction, such as raising and resuturing adjacent skin areas which might be needed for adequate closure following resection

Dr Julius McCall called attention to a serious complication that may ensue in these cases namely, a spontaneous rupture of the carotid artery In one year's time four such cases were seen at his hospital Prompt action on the part of the staff controlled them and none of them delated vocal cord action A large tubing was used in order to keep the frequencies low and the action of the stretched lip observed with a high speed camera in various phases with the air flow recorded at both input and output Changes in the dimensions and contours of the inferior surface of the glottis were observed with their effects on frequency and wave form, which pointed to the action of the subglottic portion of the thyro-arytenoideus muscle suggesting its determinant of the frequency of vocal cord vibrations

DISCUSSION

Dr Gordon D Hoople pointed out several aspects of the experiments which might be better appreciated by the viewers of the movie if samples of the sounds of the reeds could have been included on the sound strip He also suggested that the author's summary might well include a brief description of their experimental design A change in the title was also suggested, which would more accurately describe the work done Since further experiments have been projected by the essayists, no doubt the improved photographic equipment they have in mind will add much to the value of their studies

Dr Murtagh explained that they have recently been photographing the subglottic region in animals with the same high speed action analysis camera at 8000 pictures per second, which produced very instructive and revealing data The results differed from the previous experiments, which were taken at 2000, because the input pressure in the latter cases was at low frequency and thus did not require any higher speed photography Since the studies are continuing, they have tried to start from the bottom, hoping by studies at various speeds, frequencies and tensions to stumble on something of practical value

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SURGERY OF THE NECK FOLLOWING RADIATION THERAPY FOR CANCER

WALTER P WORK, M D

Dr Work reported his results with surgery of the neck in cancer cases previously unsuccessfully irradiated These cases were divided into three groups, namely nonarrested or recurrent cases of laryngeal cancer, early or late, cancer controlled by irradiation but followed by complications, and pharyngeal cancers partially or fully arrested but presenting definite indications for surgery

Surgery in cases operated upon less than one year following

NASAL INFECTIONS IN PATIENTS WITH ASTHMA AND ASTHMATIC BRONCHITIS

K M SIMONTON, M D

Dr Simonton studied the relationship between infection of the nasal sinuses and asthma in two groups of patients seen at the Mayo Clinic The first group of 252 patients yielded 186 who were referred for a rhinologic examination and among whom there were infections of the sinuses in 24, hay fever, vasomotor rhinitis or polyposis in 113 and significant anatomic abnormalities in 19 Nasal operations were done on 18 of this group, and advised in three additional cases The remainder were treated non-surgically

The second group consisted of 128 patients with a diagnosis of asthma or asthmatic bronchitis, on whom some rhinologic procedure had been performed Information on the results was available in 109 In addition to the treatment of the nose and sinuses, the usual therapy for asthma was administered

The results indicated that when infection or other nasal abnormalities were properly corrected as indicated, an improvement in the asthmatic status was noted in 44 6 per cent The results were better in females than males, also it was observed that the highest incidence of favorable results was found in the age group below 20 and above 60 Simonton explains this paradox in this manner In the young, the nasal disease has not developed to the degree warranting surgery, whereas in the old, reduced exposure to irritants incident to occupation may have been the factor

DISCUSSION

Dr Francis W Davison pointed out the complexity of the topic which makes it somewhat controversial There has always been a conflict between the allergist and the rhinologist as to relative value of etiologic factors and the methods of employing antigens for desensitization

The indications for surgery are indeterminate and variable in different hands—yet surgery is often inevitable when other therapy has failed Dr Davison has usually given antibiotic and steroid therapy a trial before resorting to surgery He would like to have Dr Simonton's views in this connection It was stated that 50 per cent of the asthmatics obtained relief from surgery Dr Davison is concerned about the other 50 per cent Why did surgery fail? It was interesting to note that females veloped cerebral complications after ligation of the common carotid, however, two of the patients died of the cancer, and the other two have shown no extension of the process in the past year and a half Dr McCall showed pictures of several cases where post irradiation neck surgery resulted in sloughing and poor healing He also suggested the preliminary raising of a skin flap for subsequent use in covering the wound

Dr John J Conley stated that the issue is critical, since a number of patients and physicians will resort to primary irradiation, and some cases have been known to respond The failures, however, are dumped in the lap of the surgeons who have to cope with a situation that is more grave than the original He also agreed that preliminary plastic procedures are of great value One must anticipate the possibility of poor healing in an irradiated area Knowing exactly how the irradiation was given, the dosage, portals, filters, etc , may be helpful in this connection Then, too, an appraisal of the condition of the neck tissues may be of help—trouble may be expected if they appear hard, board like, avascular and fixed, also the condition of the mucous surfaces must be evaluated The extent of the proposed surgery will have a bearing on the degree of anticipated trauma, the more extensive the resection the greater the trauma and the more the need for vital tissues as covering Dr Conley described several types of flaps that may be employed in these cases Involvement of the carotid arteries may be prevented if they are adequately covered by healthy vital tissues, affording a good vascular bed

Dr Samuel Salinger felt that the discussion might create the impression that irradiation for carcinoma of the larynx is never indicated This is not the case Even Dr Schall has reported a series of localized cord cancers which were cured by irradiation Cases in which the lesion is limited to one cord, is superficial, non invasive with the mobility of the cord unimpaired, are good prospects for cure through irradiation The evil results following irradiation are in many cases due to improper techniques There are some radiologists who believe that there is a certain stage in the irradiation therapy at which one can determine whether or not the lesion is responding and which is a safe time to stop and resort to surgery Just how this point is arrived at seems more or less vague Were it more definite the prospects for successful surgery would be improved Dr Work's report shows, at least, that considerable progress has been made in irradiation techniques The results in former years were uniformly bad

Dr Work replied to Dr Friedberg's query as to exploratory surgery in these cases He did not think that an irradiated larynx should be opened because of the risk of infection It is better to do the biopsies by direct laryngoscopy Preliminary reconstructive measures, as mentioned would certainly lessen postoperative complications As for hemorrhage, he had seen only one such case where the lingual artery ruptured but was promptly taken care of As for irradiation in early cases, as mentioned by Dr Salinger, he had to admit that the group of cases he has presented were not a truly representative group, being more selective He was quite sure the roentgenologists would give him a battle were they in the audience at the time He certainly would admit that many cancer cases have yielded most satisfactorily to irradiation therapy tion, mucocele, malignant growth of the nasopharynx and tumors of the pituitary gland Several aspects of the problem stand out in sharp relief, namely, the prominence of headaches, usually fronto-occipital, of long duration, the failure in most cases to suspect the sphenoid and the delay in having a thorough rhinologic examination and the value of good roentgenologic studies These points were well brought out by the essayists in the detailed documentation of their cases The headaches which they described were most severe during the night, and frequently associated with pain in the eye Ocular disturbances such as paralysis of the extrinsic muscles, optosis and proptosis were prominent symptoms in cases of expanding tumors

X-rays frequently demonstrated osteitis and osteomyelitis of the sphenoid walls In all cases a thorough examination of the nasopharynx yielded valuable information, and when intranasal surgery failed to accomplish the eradication of the disease an external transethmoid approach yielded the desired results

The authors stressed the importance of having an awareness of the possibility of sphenoid sinus involvement at all times and the value of a thorough and complete examination

DISCUSSION

Dr Arthur W Proetz approved the essayist's searching analysis of a restricted number of varying types of cases His own reaction was to point out some salient facts pertinent to the subject *1* A sphenoid infection is like a fire in a telephone exchange The symptoms show up in the outlying districts and are apt to be referable to the regions supplied by the important nerves and vessels related to the sinus 2 Low grade infections may go on for years undetected because of the location of the sinus and nature of its tissues *3* A thick front wall does not necessarily imply thickening of the remaining walls which in many instances are very thin *4* Radio opaques may yield significant information by demonstrating fitting defects 5 Laminagrams have proved disappointing because of the extreme variability in the thickness slope and distribution of the bony walls *6* The value of good X-ray pictures cannot be over emphasized especially when analyzed by an understanding radiologist 7 Fungus infection, mentioned by Dr Maxwell, is more common than generally believed, has a predilection for the posterior sinuses and characterizes the mild chronic types often with allergic manifestations Looking at the sphenoid and its vital surroundings Dr Proetz commented that we were lucky when nature put a couple of nice rugged antrums out in front to divert the passing microbe and the adventuring surgeon from the sphenoid

Dr W Likely Simpson has found the use of contrast media of great responded better than males This had not been the case in his own experience

Dr Francis L Weille called attention to a report he submitted several years ago wherein improvement in the asthma following surgery was noted in 52 per cent for six months up to 20 years The longer the patients were followed the higher the percentage of improved cases The overall results in the nose were 75 per cent He inquired of Dr Simonton just how other therapy was applied and why he thought that nasal surgery was the maximum therapy just because a high percentage of the asthmatics had sinus disease What happens to those who get better without nasal surgery of any kind? He also would like to know whether the ethmoid operations were all intranasal or external, and whether the middle turbinate was removed

Dr Oliver E Van Alyea recalled a study made at his hospital some years ago in which all asthmatics were subjected to sinus exenteration whether or not they appeared to be involved, on the basis of a direct tie up connection between the two This project failed, and the results were never published Many of these patients admitted having temporary relief, but all of them soon lapsed back to their asthmatic states Some of them were later treated for sinusitis, probably resulting from the surgery At the present time they have been doing a number of Caldwell Luc operations for the removal of polyps and diseased tissue from the antrum in asthmatics If no polyps are found the ethmoids are not touched On the subject of nasal polyps there has been some disagreement between the allergists and the rhinologists, the former being in the main opposed to the procedure

Dr Simonton replied to Dr Davison's question relating to the use of antibiotics and steroid therapy by stating that their patients had all been through a very comprehensive program of medical therapy before surgery was ever considered When indicated, antibiotics were employed, and in a group of 252 patients there were only 18 on whom surgery was performed This will perhaps answer Dr Weille's question as to the point of maximum therapy Some cases showing evidence of sinus disease were not subjected to surgery when other therapeutic measures were sufficient to afford them relief Surgery was indicated only when a chronic suppurative process was established Therapy for allergy was carried out through desensitization and the avoidance of irritants Polypi were present in most of the cases that were operated Dr Simonton feels that patients who have had polypi for a long time almost invariably develop an infection Surgery primarily was intranasal ethmoidectomy, preserving the middle turbinate and more recently transantral ethmoidectomy with attention to the antrum pathology

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THE DIAGNOSIS OF CHRONIC INFLAMMATORY LESIONS OF THE SPHENOID SINUS

J H MAXWELL, M D
and
B JAY HILL, M D

Dr Maxwell and Dr Hill presented an analysis of 16 cases of involvement of the sphenoid sinuses due to chronic infecsuitable for laryngofissure, however, when the growth has extended to the anterior commissure, the arytenoids or into the ventricle, procedures less radical than total laryngectomy were followed by a high percentage of local recurrences. The figures showed 5.2 per cent recurrence following laryngofissure, 21.4 per cent following anterior commissure technique and 82.3 per cent after partial laryngectomy.

Extra cordal cancers are so frequently associated with cervical metastases frequently undetectable by palpation that failure will frequently follow a total laryngectomy unless a neck dissection is done at the same time. The figures showed 24 per cent of failures after laryngectomy alone and 13.8 per cent after laryngectomy with neck dissection. In cases where cervical nodes were already present, the percentage of failures was 37.5 per cent when neck dissection was not done as compared to 12.5 per cent when it was.

DISCUSSION

Dr. Louis H. Clerf agreed with the essayist that failures in the surgical management of cancer of the larynx usually resulted from inadequate primary surgery. Recalling Mackenty's observation that the actual size of a cordal lesion was usually one third greater than the area visualized, he emphasized the point that the resection must be well beyond the apparent lesion if a cure is to be expected. In cases where laryngectomy is indicated he pointed out that the literature has revealed that 20 to 30 per cent of laryngectomized patients presumably free from cervical metastases develop these lesions postoperatively. In 1955, Dr. Clerf presented a study of the value of block dissection as a primary, a secondary or an elective procedure, and he feels that laryngologists should become more conscious of this trend. Elective block dissection should be considered as part of the operative procedure when laryngectomy is indicated except when the surgeon is convinced that metastasis has not already occurred. The figures presented by Dr. O'Keefe bear this out.

Dr. Julius McCall referred to his movie which was presented 14 years ago showing combined laryngectomy and neck dissection which was at that time criticized as being too radical, however today, Dr. O'Keefe's presentation fully vindicates Dr. McCall's stand. Dr. O'Keefe's survival rate is better than his own, which is 37 per cent. During the past five years at St. Luke's Hospital they have done more neck dissections in combination with laryngectomy than the latter alone. Much discussion nowadays in this connection is concerned with conserving the voice. Dr. McCall has yet to find a dead man who needed a larynx!

Dr. O'Keefe concluded by expressing the hope that further comments might be forthcoming informally.

value, and prefers to instill it into the antrum via the natural ostium As for surgery on the sphenoids, he believes the best results can be obtained only by removing the floor and intersinus septum, as well as the anterior wall

Dr John E Bordley reported that in his service most of the sphenoid sinus cases have been referred from the Neurological Service, which indicates the direct connection between infection of the sphenoid and the intracranial neurological network Recently they have had two mucoceles of the sphenoid with extension into the ethmoids Dr Bordley has found the nasopharyngoscope to be of great value in studying the postnasal and sphenoid area

Dr Edwin N Broyles recalled a case reported in Baltimore some years ago, in which a patient developed diabetes from which he succumbed, and at autopsy the sphenoids were found to be filled with purulent material It was thought that possibly the irritation of the pituitary had something to do with the development of the diabetes He asked Dr Maxwell whether the diabetes in the second case he reported had cleared up after removing the mucocele

Dr Maxwell was impressed by Dr Proetz's reference to the frequent finding of a thick anterior wall and a thin posterior wall, which has often been noted in a similar way with the mastoid He wondered why the tendency to eburnation of the outer wall should be associated with pressure atrophy and often osteomyelitis of the inner wall He does not employ contrast media routinely, although conceded their value when they can be used In some cases the ostium is inaccessible, which would preclude the passage of a cannula Laminagrams have been of value in a few instances As for the objection to using a chisel to penetrate the anterior wall, Dr Maxwell prefers the burr and curette, but in some cases, where the wall is very thick, even the chisel will require persistent hammering to effect an entrance Like Dr Bordley's experience, he, too, has found cases referred by the neurologist after having passed through the hands of other rhinologists Certainly the nasopharyngoscope is a very useful instrument, yet in cases where the sinus is closed off, it will yield no more information than the mirror In the diabetes cases referred to by Dr Broyles, it would be difficult to define the etiologic implications except to say that diabetics, being prone to infection, may harbor a long standing sinus infection which has not been diagnosed Thus the cause and effect relationship may be reversed

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CONCERNING THE CRITERIA OF OPERABILITY IN LARYNGEAL CANCER

JOHN J O'KEEFE, M D

Dr O'Keefe discussed the criteria of operability in cancer of the larynx on the basis of an analysis of several hundred cases Since the objective is the total removal of all of the involved tissues, much depends on the appraisal of the extent and location of the lesion It was found that only those which were confined to the membranous portion of the cord were

PSEUDOSARCOMA OF THE PHARYNX AND LARYNX

DANIEL C BAKER, M D

Pseudosarcoma of the pharynx and larynx was described by Baker as a non-malignant connective tissue tumor usually associated with squamous cell carcinoma Although the tissue may grossly resemble a sarcoma by reason of mitotic activity, chromatin pattern and fasciculated bands of connective tissue, the abundance of typical mitoses, and absence of nucleoli in many instances, edema and cellular infiltrate, etc , all speak against such a diagnosis Investigations by other observers indicate that the lesions are primarily squamous cell carcinoma with the secondary sarcomatous element representing a reactive phenomenon which is non-neoplastic

Three cases presented by the essayist demonstrate these points

DISCUSSION

Dr Daniel Cunning recalled that Virchow had described this tumor a century ago showing that it was both a carcinoma and a connective tissue tumor He called it a carcinosarcoma Others more recently in this country have demonstrated the same thing It would appear that the more correct term would be pseudosarcoma" since it is more often benign than malignant An awareness of this condition is important for laryngologists, since so many of these growths appear in the respiratory passages Frequently a mass appearing to be malignant is reported otherwise Yet it is important that various areas be biopsied before a final diagnosis can be arrived at The three cases presented by Dr Baker exhibit various phases of the problem First a cancer of the skin and 36 years later a cancer of the throat, all after X ray therapy in childhood Then the case of a pedunculated mass obscuring the underlying carcinoma and finally the granuloma of the trachea without any evidence of squamous cell carcinoma.

Dr Baker had nothing further to add in the discussion

CYSTIC FIBROSIS OF THE PANCREAS AND NASAL MUCOSA

MOSES H LURIE M D

Cystic fibrosis of the pancreas is a disease which involves the mucosa of both the respiratory and alimentary tracts

THE LARYNGEAL SACCULE

EDWIN N BROYLES, M D

Dr Broyles studied the laryngeal saccule or ventricle in 50 larynges (100 ventricles) removed at autopsy, 45 per cent from colored and 55 per cent from white individuals He found twice as many large saccules in the specimens of whites than blacks, and more in males than females The depth of the saccule varied from 6 to 8 mm (75 per cent) to 10 mm or more in 25 per cent, and over 15 mm in 7 per cent

These saccules can be demonstrated in tomographs, especially if of fairly large size Bilateral saccules were twice as common as unilateral

The importance of examining and studying this anatomical structure cannot be overemphasized, since it may be the seat of undetected pathology Cell studies, cultures and tomographs may all contribute to the diagnosis of concealed infection of neoplasm

DISCUSSION

Dr Paul Holinger brought up the question of the nature of the sac Does it have a thin stalk or a broad opening? If the latter, where was the point of demarcation between the saccule and the ventricle itself? Part of this question has been answered by the illustration showing the dye in the injected specimens but the dye in these appears to fill the entire ventricle rather than merely the saccule Does the saccule ever have a constricted neck opening into a larger chamber above? Potentially the sac may extend through the thyrohyoid membrane as a laryngocele or posteriorly into the aryepiglottic fold Has Dr Broyles been able to find such potentialities?

Dr Joel J Pressman told the story of a musician playing a wind instrument whose inflating laryngocele attracted more attention than his musicianship and was referred for surgery At this time, the father of the boy, an attorney, threatened to sue Dr Pressman for assault if he operated, however the young man having just reached his majority was willing and the operation was performed as per Dr DeGraaf Woodman's technique When the larynx was opened, the laryngocele was not found, but when the anesthetist put positive pressure on, it did show up and was removed Now Dr Pressman would gladly turn the patient over to Dr Broyles, who had seen him originally, and was now free to operate the other side if he wished to risk being sued for assault!

Dr Broyles stated that he believes a saccule of appendix is present in all larynges It can be differentiated from the ventricle, being merely an extension upward instead of lying just under the false cord It is usually pyramidal in contour and more frequently in the midline than anterior, rarely posterior He would be happy to have Dr Pressman operate the other side since he has already survived one risk of a suit!

it not be advisable to remove these since they so frequently are the stalks of recurring nasal polypi?

Dr Joseph P Atkins was pleased to hear the rhinological side of the picture as described by Dr Lurie He, himself, has been more interested in the pulmonary aspect of the problem Studies are in progress to determine the composition of the thick secretion which clogs the air passages In the meantime, mechanical aspiration of these secretions has been of some considerable help

Dr Lurie explained that the cocaine solution he has been using is a 1/5 of 1 per cent solution which being employed off and on has proven very effective and has never caused any outward symptoms Naturally it is not to be used indiscriminately As for surgery Dr Lurie has found that the disease is not limited to the antrums, and consequently it is often necessary to clear out the ethmoids and often the frontal Antrums that have been opened for the second time have revealed persisting function of the lining as evidenced by mucous secretion and goblet cells Dr Lurie did have one case in a child where the middle ear contained a very thick gluey mass which, when extracted retained the shape of the cavity As Dr Atkins said it is not safe to use atropine or scopolamine in these children Dr Lurie confessed that he doesn t often see the cases when the pulmonary symptoms predominate, because these are already in the hands of the chest surgeons It would be well that the chest men be aware of the frequent association with sinus pathology and consult with the rhinologist Replying to Dr Van Alyea he stated that he does remove polypi whenever the diagnosis is certain

CAUSES OF FAILURE IN SURGICAL TREATMENT OF MALIGNANT TUMORS OF THE LARYNX

CHARLES M NORRIS, M D

Norris attributes failure following surgery for carcinoma of the larynx to delay in diagnosis, inaccurate appraisal of the extent of the lesion, insufficient biopsy and incomplete removal

Improvement in percentage of five-year cures is attributed to wider variety of procedures for partial laryngectomy and the recent trend toward more frequent neck dissection The procedures advocated for invasive lesions of the middle third of the cord, extension into the ventricle and minimal subglottic extension are the fronto-lateral resection with removal of a vertical anterior segment of the thyroid cartilage and an extended form with use of skin graft and mold Of 209 cases undergoing initial partial laryngectomy the incidence of failures due to recurrence was 7 2 per cent and those due to

Respiratory tract symptoms appear early with repeated colds, wheezing, nasal obstruction, dry cough, bronchitis, bronchopneumonia, bronchiectasis and ear infections The submucosal glands are involved and secrete a viscid mucopurulent discharge This disease is accompanied by a high concentration of sodium and potassium chloride in the perspiration, and a simple test devised by Shwachman and Gaha may help to differentiate nonspecific mucosal affections from a true cystic fibrosis of the pancreas The test consists of placing the patient's hands and fingers on a specially prepared agar plate which has a definite amount of silver nitrate and potassium chromate A high concentration of chlorides in the sweat will cause a deep discoloration, and the degree of discoloration arbitrarily decided as one, two and three will so indicate It has been found that in 140 cases of cystic fibrosis, 138 gave a three plus reaction whereas in 77 normal children the reaction was one plus in 65

These cases should be treated symptomatically and conservatively, avoiding surgery except for removal of polyps

DISCUSSION

Dr Bernard McMahon called attention to the nasal symptoms which often suggest an allergy Hyperactivity of the glands results in a discharge of mucous, often quite thick As a result, the ducts of the glands become blocked, and the mucosa herniates forming polyps Frequently the staphylococcus is found on culture Sensitivity tests are not always conclusive, but chloramphenicol seems to be the most effective antibiotic Surgery is not indicated in these children, but it is important that the nasal symptoms be recognized as due to the general process and treated as part of the whole Dr McMahon inquired about the use of a 5 per cent cocaine solution mentioned by Dr Lurie Did he not think there was a possibility of toxic reactions if the solution were accidentally swallowed

Dr Robert E Priest asked Dr Lurie whether he had found any serous otitides of the gluey type in fibrocystic disease

Dr Daniel C Baker, Jr, mentioned that he is associated with a New York hospital where Dr Dorothy Anderson, who described this disease, is the pathologist The laryngologist is interested in the process because these patients are often referred to him because of the nasal or the broncho pulmonary symptoms He has noted the fact that this disease is only one which will produce nasal polyps in a small child In patients with pulmonary symptoms one must avoid the use of atropine or scopolamine when surgery is performed, because of the tendency to a foreign body reaction which may result in pulmonary insufficiency This latter has been noted in cases where the disease has affected older age groups—individuals in their 20's

Dr Oliver Van Alyea thought that several of the X ray pictures shown by Dr Lurie disclosed what appeared to be polyps in the antrum Would some cases the partial laryngectomy is more radical than a simple total laryngectomy Reports such as Dr O'Keefe's and Dr Norris' are valuable because of their analysis of the material from the anatomical viewpoint Terms such as "intrinsic" and "extrinsic" are obsolete Another important point is the value of consistently tenacious following up of the cases It is equally as bad not to hear from patients who have been recovered for more than five years as to fail to be notified of the death of some who did not survive

Dr Norris was glad to hear Dr Putney's warning about the danger of carrying cancer cells into the lower respiratory tract by the passage of a scope through the affected area in the larynx Dr Reed's comment that doubtful nodes must be considered malignant rather than otherwise is well taken He further expressed his appreciation to Dr Jackson for his suggestion in the matter of classifying these growths

HISTOCHEMICAL STUDIES OF THE PATHOGENESIS OF NASAL POLYPS

ALEX WEISSKOFF, M D ,
and
HELEN F BURN, M S
(By Invitation)

Weisskoff and Burn made a study of polyps removed from 23 patients, 17 being allergic, three infective and three with abnormal mucosa from the antrum, in order to ascertain the nature of the nasal polyp They found that the histochemical procedure was superior to simple hematoxylin eosin staining, particularly in defining the so-called basement membrane which turned out to be a dense collagenous infiltration with very little of the acid mucopolysaccarides, which are a constant component of the basement membrane

Histochemical studies revealed the constant presence of acid mucopolysaccaride ground substance in all polypoid tissue, even in the so-called edematous cyst, also, an increased amount of ground substance with increased tissue activity as evidenced by increase in primitive fibroblasts and capillaries They found evidence that the primitive fibroblast or mesenchymal cell, as well as the endothelial cell, is active in the formation of the ground substance

The presence of active connective tissue elements, both cellular and stromal, suggests that the polyp is more than metastases 2 4 per cent. Nine of 15 recurrences were salvaged, eight by further operation and one by irradiation

In 181 cases of laryngectomy without simultaneous neck dissection the incidence of recurrence was 11 6 per cent, and that of cervical node metastasis without recurrence 20 4 per cent

Postoperative metastasis after laryngectomy without neck dissection, studied in relation to location of the laryngeal lesion, occurred in 6 per cent of the endolaryngeal, 16 per cent of the subglottic, 29 per cent of the vestibular and 42 per cent of the marginal cases Better results were obtained in 22 cases where the neck dissection was simultaneously performed with the laryngectomy It is conceded that neck dissection is indicated in most laryngectomies even though palpable cervical nodes are absent

DISCUSSION

Dr F Johnson Putney explained the finding that all of the patients developing cervical node metastasis after partial laryngectomy failing to recover, as being due to an exceedingly rapidly growing and undetected early metastasis even in the presence of a small lesion Mobility of the cord is a good criterion on which to base the indications for various procedures, but is sometimes difficult to determine, especially if the arytenoid alone is mobile Superficial cord lesions with good cord mobility are favorable for irradiation if administered by a roentgenologist who is familiar with larynx pathology Cancer developing adjacent to the stoma or peritracheal carcinoma represents metastasis to the paratracheal lymph nodes Cases of associated carcinoma of the lung and larynx are frequently entirely separate lesions Putney deplores the practice of passing an endotracheal tube for anesthesia through a larynx containing carcinoma because of the danger of implanting carcinoma cells in the deeper structures He agreed that the prophylactic neck dissection is indicated in all cases except cordal lesions Bilateral neck dissection, when indicated, should be done in two stages

Dr George F Reed added his approval of neck dissection in all cases involving more than the cordal area He feels that the expectant attitude in cases where palpable nodes are not found, is an illusory crutch that should be discarded He will be reporting on an analysis of 200 cases from the Massachusetts Eye and Ear Infirmary, showing that in cases where positive nodes were found on neck dissection only 17 per cent survived for three years

Dr C L Jackson felt that there was too much controversy in the matter of conservative vs radical surgery In the words of Professor Sebileau of Paris surgery shall be “A la demande de lesion ” The thing to do is always to be critical of our procedures and seek to benefit by our experience As Dr Norris has indicated the procedures at the Jackson Clinic vary from limited cord resection to laryngopharyngectomy and bilateral neck dissection The laryngofissure operation they perform is a form of partial laryngectomy, of which there are several varieties In

Wegener's syndrome, and is unaccompanied by renal involvement The condition must also be differentiated from Boeck's sarcoid, polyarteritis nodosa and specific granulomas

Wegener's granulomatosis is classified as being within the group of diffuse collagen diseases The lesions may involve areas in the upper respiratory tract, the lungs and bronchi and the kidneys, all of which reveal signs of vasculitis of varying degrees Cutaneous lesions have also been observed

Seven cases are presented and thoroughly analyzed Three of these seemed to represent early or non-fatal variants of the syndrome

DISCUSSION

Dr Henry L Williams expressed his dislike for eponyms, preferring that a syndrome or disease be given a term or name that would give some hint of the pathologic process As to the authors' attempt to differentiate the so called "Wegener's granulomatosis" from lethal granuloma on the basis of the former's being associated with lesions in lower respiratory tract, the latter's being restricted to the middle of the face, Williams countered with the statement that such lesions are common in both disorders As a matter of fact, he pointed out that generalized lesions in the kidneys, lungs skin and blood vessels are found in a number of diseases, such as verrucous endocarditis with disseminated lupus erythematosis nonspecific interstitial keratitis and periarteritis nodosa all being varieties of collagen disorders In his opinion, all of these conditions, including those under discussion, are fundamentally periarteritis nodosa with unusual prominence in one or more organs Since the diagnosis of this process is very difficult, pathologists are often led astray A correct diagnosis requires the ruling out of such disorders as iodism, glanders, tularemia, leprosy rhinoscleroma blastomycosis etc Even to rule out reticulosarcoma and epithelioma with necrobiotic tendencies takes repeated deep biopsies and study Midline granuloma is a collagen disease as evidenced by its response to steroid therapy Cases that have improved following Roentgen therapy would more likely be reticulosarcoma than a true collagen disease, furthermore cases of lethal granuloma in several instances have been proven to be epitheliomas after thorough study of the biopsies It is therefore impractical and misleading to apply a descriptive term to a condition which may be only one manifestation of a more fundamental process which is as yet not fully understood and is particularly difficult to diagnose

Dr Barton related his experience with a case that appeared to be a progressive atrophic rhinitis with saddle nose and inspissated dried mucosa and a granulated appearance to the mucosa, but which in his opinion was a more serious condition for, despite antibiotic and other therapy, the patient died and the autopsy diagnosis was "Wegener's Granuloma" Since the patient had been at the U C L A Medical Center it was Dr Barton's hope that Dr Pressman might have seen her there and could elaborate on the latter stages of the case

Dr Pressman stated that he hoped that it would not be assumed that there was any relationship between the patient s being sent to U C L A and the bad prognosis given at the time!

edematous nasal mucosa, it appears to be a connective tissue response to chronic stress of the nasal membranes

DISCUSSION

Dr Walter P Work commented on the similarity of the ground substance content of both the inflammatory and allergic polyp Vagaries of the histochemical method can be controlled, to some degree, by using fresh testicular hyaluronidase and umbilical cord in each staining group These studies show that edema, previously considered to be fluid accumulation, really consists of pools of mucopolysaccarides of varying degrees of polymerization The concentration of this material in the endothelial cells suggests the possibility of further studies on such lesions as atrophic rhinitis, midline granulomas and similar processes The relation of these substances to adrenal cortical secretions has been the subject of some investigation in recent years and should provide an area of worthwhile research

Dr Harry P Schenck believes that Dr Weisskoff's findings will help to confirm the results of electrophoretic studies previously reported, delineating the protein structure of the polyp While there was no increase in the protein content, they found an increase in the gamma globulin with 100 times the amount of specific antibodies concentrated in extracts of polyp fluid This procedure is not easy in many cases when the polyps are more solid As a matter of fact, nasal polyps should be called myxoid fibromas or fibromata, also the more plasma cells that are found, the greater the concentration of gamma globulin On the other hand, the gamma globulin had no connection with the number of eosinophiles present Such investigations as the one reported by Dr Weisskoff should be of great help in clarifying some of these points

Dr Weisskoff agreed with Dr Schenck that in most cases the term "myxoid fibroma" fits the pathologic picture best The work just reported will be carried on with several other connective tissue histochemical stains and at least a dozen enzymes, which by breaking the findings into various categories, should be fruitful of decisive findings

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WEGENER'S GRANULOMATOSIS

JOSEPH P ATKINS, M D ,
and
SYLVAN EISMAN, M D
(By Invitation)

Wegener's granulomatosis is described as a syndrome consisting of necrotizing granulomata of the upper and lower respiratory tract, generalizing necrotizing vasculitis and glomerulitis leading to uremia and death

It is to be differentiated from lethal midline granuloma in that the latter fails to show the vasculitis which characterizes

3 Linear shortening of the aortic implant which had united with the trachea increasing the spaces between the rings

4 Tracheal cartilage adjacent to the anastamosis exhibited calcification and metaplasia into true bone

DISCUSSION

Dr Daniel C Baker complimented Dr Pressman on this fine piece of fundamental research It would appear that an aortic graft could prove to be a satisfactory replacement for an excised trachea, certainly superior to foreign body implants such as nylon, dacron, etc In his own experience he had never had a case which required total circumferential excision of the trachea In one instance a traumatically severed trachea was reunited after pulling the lower portion up out of the chest into which it had receded The idea of mobilizing the lower trachea for resuture to the upper portion has been advocated and practiced by thoracic surgeons He would like Dr Pressman to relate whether he had personally had an experience with such procedures

Dr John J Conley commented on Dr Pressman's reference to serendipidy in connection with his investigation From the laboratory point of view four items of interest emerge from the investigation namely leukoplakia from the pressure of the acrylic stretching of the residuum of the trachea retention of elastic tissue in the aortic transplant and metaplasia in the cartilage rings Although the clinical value for humans is practically nil the experiment has great value for the positive facts elicited Survival of homografts varies according to the tissue involved, the cornea and cartilage heading the list Dr Pressman's studies revealed the fact that the elastic fibers of the transplant survived above all the other components yet, replacement of large segments of the trachea is still an unsolved problem although defects up to 3 cm may be closed by approximation To ease the stretching of the trachea one can accordionize' it by cutting between the rings Larger defects can be closed by free tracheal implant which is a composite graft taken from the lower trachea Dr Conley then described processes involving the use of homologous materials and his procedure for correcting major defects

Dr Alexander Weisskoff was deeply interested in the slides showing the elastic fibers and the conflict between the tissues surviving and those succumbing to fibrous connective tissue inroads A chronological sequence of slides could afford exceedingly valuable information on the basic understanding of connective tissue Recently a connective tissue fiber found in the Achilles tendon, and another between the tooth root and surrounding connective tissue have been described Special stains in Dr Pressman's series might bring out some new information particularly with reference to the bony metaplasia he observed

Dr Pressman stated that although he had avoided reference to the clinical application of his work the possibilities are nevertheless in the background Certainly as pointed out by Dr Conley partial defects of the trachea can be effectively closed by aorta transplant as long as the defect is not circumferential Such a covering supplies not only support but also an epithelial lining, and prevents occlusion by ingrowing granulations A point was mentioned about the experimental dogs Those with aortic implants did not die they were sacrificed at will The dogs that carried only polyethylene tubes survived as long as the granulations were taken care of

Dr Walter B Hoover thought some of the comments made by Dr Williams should be emphasized As long as the etiology is unknown it is best to call all these midline lesions granulomas Confusion will still exist, as evidenced by three cases he had seen where competent pathologists reported their diagnosis as lethal granuloma, whereas biopsies from areas remote from the ulcerative lesion proved to be lymphoma or lymphosarcoma Another case with lesions involving the nasal mucosa had partial turbinotomies done to establish an airway, and the tissue was declared to be nonspecific granuloma After a symptomless interval of two years, the lesions recurred and now involved the external nose and forehead The biopsies again were indeterminate X rays followed by steroid therapy brought about considerable improvement Thus all one could conclude was that the steroid therapy was of value though the diagnosis was still uncertain

Dr Atkins agreed with Dr Williams that the linking of names to syndromes is undesirable and that descriptive terms are preferable, however, until we have some idea where we are going we have to follow the literature as it has developed Whether the condition is a periarteritis nodosa or some other disease we do know that we have a condition which may involve both upper and lower respiratory tracts, but is also a disease which involves the entire economy Dr Atkins would not disagree with Dr Hoover since both he and Dr Williams pointed to the positive diagnosis of a specific condition when taken at a point remote from the ulcerated area

THE EXPERIMENTAL USE OF HOMOGRAFTS FOR REPAIR OF THE CERVICAL TRACHEA

JOEL J PRESSMAN, M D

Reporting the results of his experiments on 200 dogs, Dr Pressman introduced the word "serendipidy" as being applicable in this connection, inasmuch as information that was not anticipated resulted from the experiments, though the original goal sought for was not attained

Preserved sections of aorta over polyethylene tubing were used in these dogs to supplant excised segments of the trachea After a lapse of from a few months to three years, the tissues were excised and examined

The following results were noted

1 The prolonged indwelling polyethylene tubes brought about a leukoplakia

2 The aorta retained much of its original structure showing especially the persistence of the elastic fibers despite marked contraction due to fibrosis

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Time 6 30 P M last Monday of each month from September to June, inclusive—Otolaryngology Section 6 30, first Thursday of each month from September to June, inclusive—Ophthalmology Section

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Time and Place Miami, Fla, March, 1960

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A STUDY OF THE FATE OF AUTOGENOUS CARTILAGE GRAFTS*

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I INTRODUCTION

The present study was done to investigate generally, the fate of autogenous cartilaginous transplants in the external ears of animals, and to determine specifically whether the union that takes place between a carefully approximated autogenous graft and its host cartilage is fibrous or whether new cartilage is formed It was felt that this study may give some clue as to the fate of the cartilaginous portion of a composite graft from the ear of humans for transplantation to defects in the external ear, ala nasae, and columella A composite graft is defined as one that contains more than one type of tissue, such as both cartilage and skin In this instance, however, only the cartilaginous portion is being considered The cartilage of the ear of the rabbit was selected, because it so closely resembles the elastic cartilage in the ears of humans

According to the microscopic appearance and nature of its fibrillar components, three varieties of cartilage are distinguished hyaline, elastic, and fibrous Hyaline cartilage has the widest distribution throughout the body and is characterized by a matrix that is almost clear and translucent and is free from obvious connective tissue fibers Elastic cartilage

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possesses cells like those of hyaline cartilage, but the matrix contains numerous branching elastic fibers. Elastic cartilage is found in the external ear, ear canal, Eustachian tube, and epiglottis. Fibrocartilage has a cellular structure like hyaline and elastic cartilage, but the matrix contains thick, compact collagenous bundles which lie parallel to one another. Fibrocartilage is found in the intervertebral discs, symphysis pubis, and the interarticular menisci of many joints.

The voluminous literature dealing with cartilage grafts is, for the most part, contradictory and confusing as regards any conclusions. This is primarily due to the variations in the different experimental procedures utilized. The autogenous grafts of cartilage have, for instance, been subjected by many investigators to removal of the perichondrium, to boiling, freezing, dehydration, etc. The laboratory animals commonly used have been rabbit, chicken, mouse, guinea pig, and dog. Grafts have been taken from rib, ear, joint, sternum, and other sites and inserted in subcutaneous tissues, intramuscular areas, anterior chamber of the eye, and joint synovial cavities.

A summary in chronological order of the more pertinent findings reported in the literature is presented.

II. REVIEW OF THE LITERATURE

1. *Literature Previous to the Twentieth Century*

The earliest writers were primarily concerned with the healing of wounds or injuries to cartilage. Hunter[1] (1743), Dorner[2] (1798), Meckel[3] and Pauli[4] (1854), and Leidy[5] (1849) agreed that cartilage had no tendency to regenerate or unite after injury. Redfern,[6] who in 1851 used a microscope for observations, reported that healing of wounds in rib and ear cartilages was accomplished by ingrowth of fibrous tissue and some activity on the part of the cartilage cells at the edges of the wound. Two years later, in 1853, Kolliker[7] and Paget[8] found no evidence that fragments of cartilage united after injury or rupture, and further stated that new cartilage does not replace damaged cartilage. Bert[9] (1865) was presumably the first to report viability of cartilage with transplantation He buried a rat's tail beneath the skin as an autogenous graft and noted that the cartilage remained viable for months Ollier[10] (1867) was in agreement with Bert and further stated that adult animal cartilage will survive when transplanted if the perichondrium remains attached to the graft Fisher[11] (1882) agreed that perichondrium was necessary for survival of a graft Zahn[12] (1884) believed that all cartilage grafts tended to undergo degeneration regardless of whether they were homogenous or autogenous On the other hand, Prudden[13] in 1887, substantiated Bert's observations and since he removed the perichondrium from the transplants apparently proved that cartilage can survive without the perichondrium He transplanted small pieces of hyaline cartilage to the subcutaneous tissue of rabbits and allowed them to remain in place as long as 399 days He believed the cells lived for many months and even changed in size and shape

The first use of cartilage transplants in humans is credited to Konig[14] (1896), who used them to repair tracheal defects with successful results

At the beginning of this Century the interest turned more intently to the histological changes responsible for healing of wounds in cartilage

2 *Literature from 1900 to the Present*

Matsuoka[15] (1904) and Mori[16] (1905) agreed that cartilage injuries healed by the proliferation of a layer of connective tissue from the perichondrium which became partly changed into fibrocartilage Seggel,[17] (1904) however, was of the opinion that cartilage cells multiply by mitosis Haas[18] (1914) concurred with Matsuoka and Mori in stating that regeneration of cartilage was from the perichondrium Fisher[19] (1922) seemed to agree with Seggel, as he found that superficial cartilage cells became the parent cells of the more fully developed cartilage in its deeper parts Ito[20] (1924) further substantiated the work of Matsuoka and Mori He worked with the articular cartilage of rats and found that defects in the grafts were first filled with granulation which in time changed into fibrous tissue, then to fibrocartilage, and finally into cartilage It would appear that the writers in the early part of the Twentieth Century were in agreement that cartilage does tend to regenerate following injury There was no agreement concerning the process by which healing took place

The work of Loeb[21] (1926) remains a classic to this day He found that cartilage and its attached structures such as perichondrium, fat, and areolar tissue remain well preserved after autotransplanation Homotransplants of cartilage, on the whole, remained well preserved It was his contention that the perichondrium may form new cartilage in both instances He noted a great difference in cellular response evoked by autotransplants of cartilage as compared with homotransplants of cartilage After autotransplantation, lymphocytes were almost entirely lacking, whereas in the homotransplant there was a considerable lymphocytic response He found that lymphocytes entered necrotic areas of cartilage and replaced them, but that they migrated only to a very limited degree into living, well-differentiated cartilage where they soon perished Lymphocytic invasion became enhanced if the intercellular substance was decreased

Key[22] (1931) was of the opinion that the repair of defects in hyaline cartilage occurred through the proliferation of fibrous tissue with transformation into cartilage Publishing in the same year, Shands[23] was largely in agreement with Key He stated that following injury, fibrin was first laid down, to be followed in turn by granulation tissue and connective tissue Cartilage cells that began to form in the connective tissue became fibrocartilage which developed into new hyaline cartilage A year later, Fell[24] stated that perichondrial cells possessed the specific power to form cartilage cells

It was in 1939 that Peer[25] published the first of his excellent and voluminous works with cartilage grafts After burying autogenous rib cartilage grafts for four-and-a-half and six years he found them to be living cartilage when removed He concluded that this type of graft survived up to six years and remained the same size Dupertius[26] (1941) demonstrated the actual growth of transplanted young cartilage and believed that the increase in size proved the viability of the transplant His studies were further extended, and in 1950[27] he demonstrated a measurable growth of autogenous cartilage transplants in humans This was accomplished by inserting a piece of rib cartilage into the dorsum of the nose of young children He reported an increase in length of the graft that was measurable In addition, he was of the opinion that perichondrium was not necessary for the growth

Clark and Clark[27] by means of their transparent chamber installed in the rabbit's ear, observed the late formation of new cartilage After vascularization of the area was completed new cartilage cells were seen to arise from elongated motile cells The latter contained uniformly distributed granules that enlarged and coalesced to form fat droplets similar to those seen in the intact ear cartilage and matrix which appeared simultaneously between the cells They were unable to determine the origin of the new cells but believed they were either from the original cartilage and perichondrium or from fibroblasts arising from the connective tissue The fact that the new cartilage was spotty in distribution was interpreted as probably indicating a stimulus of the nature of a localized chemical change in the tissues In addition, there was occasionally some development of new bone in the midst of an area of new cartilage

Young[28] (1941) found that autogenous rib cartilage grafts to the abdomen remain viable In all of his specimens the cellular structure was found to be intact, the cell nuclei were present, and the grafts were pliable and retained their spring-like elasticity In another experiment, Young placed fine particles of chopped cartilage into the abdominal wall without or with perichondrium and found that all the particles were viable on removal and had become adherent to one another by fibrous tissue

Peer[29] in 1944 wrote that autogenous cartilage is the material of choice for transplantation in that it survives as living tissue, is not subject to invasion or absorption, and remains as part of the living organism He emphasized that the matrix of cartilage gives this structure its property of elasticity which adapts it for special function or support The ultimate survival of a graft is determined by the living cartilage cell since this cell produces the matrix In addition to proving the viability of his grafts, Peer[30] writing two years later substantiated the work of Dupertius, but in the human He took measured pieces of young autogenous grafts from the rib, nasal septum, and ear, with the perichondrium removed, and buried them for intervals up to two years There was a definite increase in size of the transplanted tissues

Brown, et al ,[1, 13-14] presented three papers in 1946, dealing with the successful use of composite grafts of skin and cartilage from the ear in humans to replace the loss of tissues from such areas as the nostril border, nasal tip, and columella Since the original paper by Brown in 1946 other papers presenting the successful use of composite grafts have been published Brown[11] (1947), Wachsberger[4] (1947), Szlazak[1] (1949), Converse[17] (1950), Dufourmental[19] (1951), Farina[11] (1952), and McLaughlin[10] (1954) Brown states that the transplanted cartilage does persist and can be felt in the grafted area months after surgery

Peer and Walker[10] (1951) found that free human cartilage autografts in contact with like tissues retain their specific structures and that cartilage autografts in contact with unlike tissues can survive transplantation unchanged and retain their same relative size It was their finding that cartilage transplants in the human are joined to the host cartilage by fibrous union and not by cartilaginous union

Laskin and Sarnat[15] wrote the first of their articles on the respiration and anaerobic glycolysis of transplanted cartilages in 1952 They found the rate of respiration and anaerobic glycolysis of fresh rabbit costal cartilage to be among the lowest of all tissues They determined that cartilage metabolism is predominantly anaerobic, and that transplantation resulted in a decline of approximately 45 per cent in the rates of both respiration and anaerobic glycolysis in both autogenous and homogenous grafts during the first seven days They could find no difference after seven to 150 days between metabolic activity of costal cartilage autogenous grafts or homogenous grafts In papers published in 1953 and 1954, Laskin and Sarnat[14] found that cartilage grafts were able to survive because the metabolism of the grafts was very low, and thus the factor of complicated cellular and immunologic response of the host as occurs in grafts of higher metabolic response was either eliminated or decreased. Because cartilage exhibits a predominantly anaerobic metabolism it can better withstand the hypoxic states during transplantation, and being avascular, it can more readily establish its normal diffusion pattern with the surrounding tissue fluids.

In the 1952 edition of their textbook, Maximow and Bloom[45] stated that after a wound or excision of a portion of living hyaline cartilage in adult mammals regeneration does not take place.

Longmire, et al.,[46] writing in 1954, believed there was almost universal agreement concerning the superiority of autogenous grafts over homologous tissue grafts. They felt that it was the general impression that autogenous grafts of all kinds are less susceptible to infection, inflammatory reaction, absorption, or other physical alteration than comparable homologous grafts.

Billingham[47] (1954) stated that the actual cells in cartilage grafts, even in freshly removed and transplanted grafts, die very soon after transplantation. The reason was presumably due to a delay in the penetration of host vessels into the grafts and, therefore, play practically no part in the healing process.

In 1954, Peer[48] wrote that normal growth of all cartilage structures during childhood takes place from the deep layers of connective tissue cells of the perichondrium which form a matrix about themselves, separate from the perichondrium and become cartilage cells. He stated that cartilage ceases to grow after adulthood is reached.

Rao[50] (1954) reported his experimental results on the regeneration of cartilage in rats. He incised the sternum in the midline and kept the divided parts in apposition by sutures. The healing process was studied at intervals. After two days the areolar tissue surrounding the cartilage was edematous. After four days the gap between the cartilage was filled with fibrin clot, cellular infiltrate with edema, and congestion of the fatty tissues. After seven days the fibrin clot underwent organization, edema was reduced and fibroblasts developed from fibrous fascia and perichondrium. After 15 days the fibrin was invaded by granulation tissue, and the cut ends of the cartilage were irregular due to the outflow of hyaline matrix After 28 days there was a cluster of new cells Between 30 and 50 days the cut edge of the cartilage increased in size due to a greater amount of hyaline matrix and proliferation of cartilage cells After 90 days the gap between the cut ends was filled with fibrocartilage and closely resembled young cartilage cells Toluidine blue stain showed the matrix in stages of transformation into hyaline ground substance At 114 days the new cells and matrix resembled original cartilage and differed only in the absence of cell arrangement of lacunar spaces and columns The matrix lacked the brilliant color reaction with McManus's stain which suggested a deficiency of chondroitin sulphate He believed the proliferation of cartilage cells occurred by mitosis This process was slow, sporadic, and incomplete He stated that the fibrous tissue was derived from the perichondrium as well as the surrounding connective tissue

Gibson[41] (1955) was of the opinion that cartilaginus repair occurred in three possible ways proliferation of chondrocytes, proliferation of vascular connective tissue from the perichondrial margins and by the ingrowth of vascular connective tissue

Craigmyle[42] (1955) reported on experimental studies with cartilage grafts in rabbits and concluded that cartilage retained its structure after autotransplantation, and that grafts appeared to remain viable

Peer,[51] in his excellent book of 1955, stated that there is no evidence that cartilage unites by other than fibrous union in humans

III METHOD APPROACH TO THE PROBLEM

Five healthy adult white rabbits weighing approximately five pounds each were selected for this study Anesthesia was obtained by the subcutaneous injection of pentobarbital sodium In all, ten separate cartilage grafts were obtained for study for periods varying up to 150 days

Each transplantation was prepared using aseptic surgical technique The skin over the ear was shaved, cleansed with soap and water and alcohol applied Each area was draped with sterile towels Fine forceps, small curved scissors, and small eye needles were used Hemostasis was obtained by the use of small hemostats and fine silk sutures The edges of the wound were carefully approximated with silk sutures

An elliptical incision of about 15 mm in the greatest diameter was made in the skin in the mid-portion of the ventral surface of the ear The skin was carefully elevated with sharp dissection by scalpel and scissors, care being taken to avoid any injury to the underlying perichondrium A previously sterilized cork-borer with a diameter of 7 mm was employed to cut through the perichondrium on the ventral surface, the cartilage, and the perichondrium on the dorsal surface of the ear Care was taken to avoid cutting the skin on the dorsal surface of the ear The cork-borer was used because it could be readily sterilized and was easily sharpened It cut the graft and the recipient bed of exactly the same diameter The circular piece of cartilage was then removed from its bed by sharp dissection and placed in a similarly prepared bed in the opposite ear The graft fitted snugly into the recipient area, and it was not necessary to employ sutures to hold it in place All the animals tolerated the procedure well

The animals were sacrificed at intervals of 30 days An incision through the skin was made and another circular piece of cartilage and its attached perichonrium was removed At this time, however, the piece of cartilage removed was approximately 3 mm wider at its periphery than the original graft to include the point of union and the surrounding cartilage

The specimens were fixed in 10 per cent formalin for four to seven days They were then rinsed in water and dehydrated in alcohols (50 per cent, 70 per cent, 80 per cent, 90 per cent, 95 per cent, and absolute), for three to four hours in each, following which each was cleared in cedarwood oil and finally infiltrated and embedded in 56° C paraffin Sections of 5 to 10 microns in thickness were made through the specimen in a horizontal plane They were mounted and then stained with Harris hematoxylin and eosin

IV FINDINGS

Macroscopic examination of the grafts on their removal prior to fixation, staining, and sectioning revealed them to be quite flexible and elastic There was no visible difference in texture between the graft and surrounding cartilage In the 30, 60, and 90 day grafts there was evidence of a slight circular cut In the 120 and 150 day grafts, the graft and the host cartilage appeared to be continuous

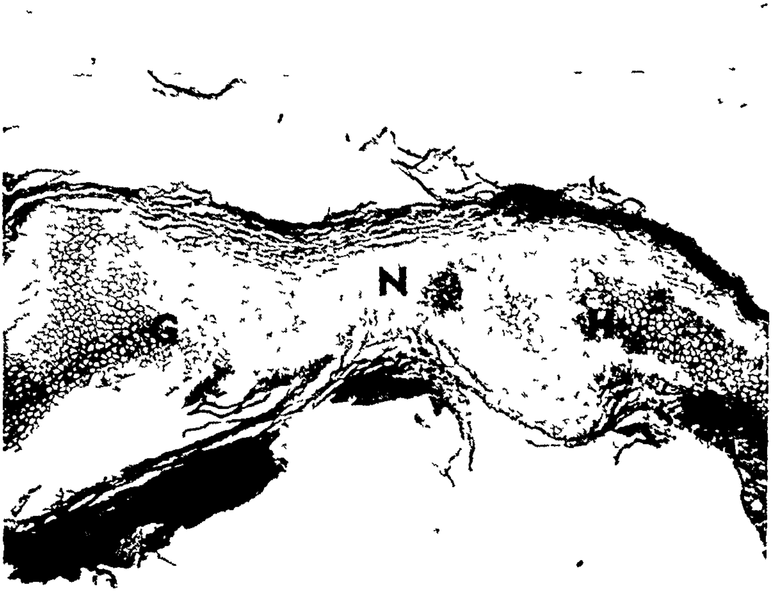

Fig 1 A photomicrograph of a section through the junction between the host and graft cartilages after 30 days The union at this time for this specimen is cartilaginous *To the left is the graft (G)* The cartilage is in a viable state although it is not particularly adherent to the surrounding connective tissue To the right is the host cartilage (H) with perichondrium and surrounding tissues intact There is proliferation of perichondrial cells on either side of the host cartilage for a short distance and it is presumed that *most of the* union between transplant and host is from the intact *perichondrium of the host* Note the irregular arrangement and *size of new cartilage cells (N)* and the tendency for the new cells to occur in groups with varying amounts of matrix about them Six microns in thickness Harris's hematoxylin and eosin 25X

The junction between host and transplant *cartilages* after 30 days is illustrated in Fig 1 Young cartilage cells unite the two tissues There is evidence that the perichondrium of the host cartilage has been the chief factor in the production of the newly formed cartilage The thickened and active perichondrium of the host cartilage is in contrast to that of the graft At this stage the subcutaneous tissues on either side of the graft cartilage have not become firmly attached to it

Fig 2 shows an area of new bone formation occurring in the new cartilage after 60 days Fibrous tissue is seen to unite the host and graft cartilages There are a number of small blood vessels in the area encircled by bone It appears to have a rather dense fibrous connective tissue about it The proliferation of new cartilage cells from the perichondrium of the host cartilage is in contrast to the less active perichondrium of the graft The latter cartilage has maintained its

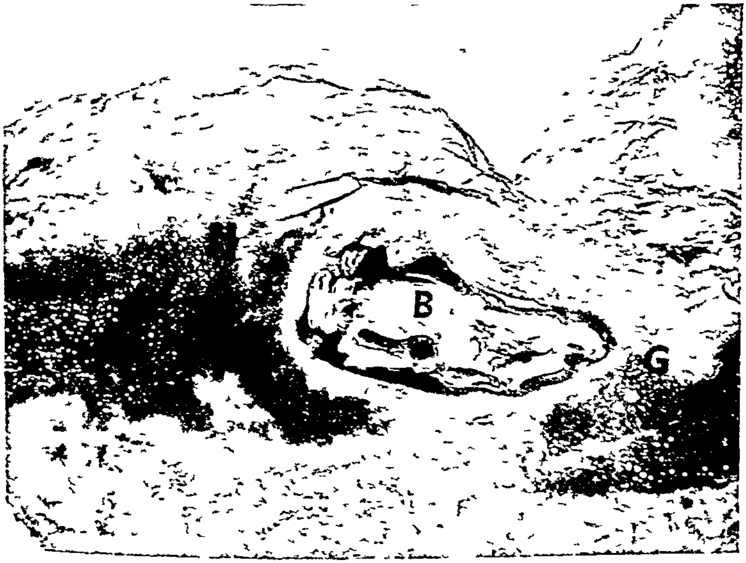

Fig 2 A photomicrograph of the union between host and transplant cartilages after 60 days The host cartilage (H) is to the left and the graft (G) is to the right Between the two is a cartilaginous and fibrous union in which new bone formation (B) has occurred The perichondrium on the side of the host cartilage shows considerable activity and the formation of new cartilage cells The perichondrium of the graft cartilage while relatively inactive is closer to the new bone which encircles a more vascular area The graft at this stage is firmly attached to the surrounding connective tissue Six microns in thickness Harris s hematoxylin and eosin 25X

viability, and the surrounding connective tissue is firmly attached to it

A somewhat higher power view of the union between the graft and host cartilages after 90 days is shown in Fig 3 Most of the newly formed cartilage cells are small with more matrix between the cells than is seen in the 30-day and 60-day specimens On the border of both host and graft cartilages an area of irregularly arranged and larger cells appear to be undergoing rapid division There is, in addition, an area designated by "D" which shows degenerative changes in presumably mature cells of the graft cartilage This type of alteration was found to occur in most of the specimens but never involved the greater part of the graft, and was usually a small area located on the periphery

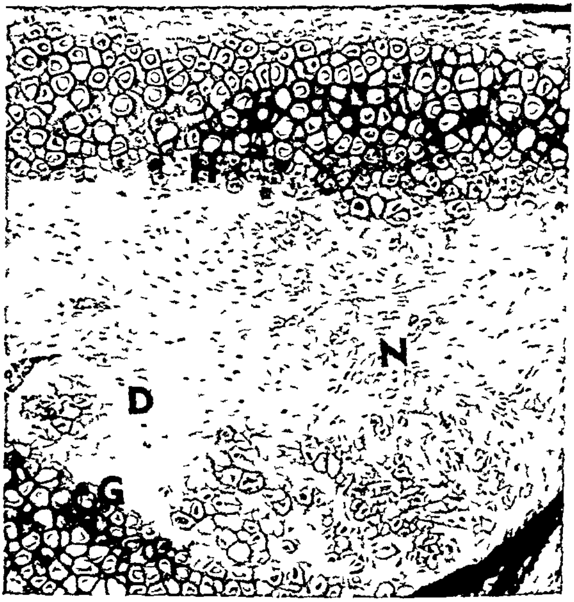

Fig 3 A photomicrograph of the union between graft and host cartilages after 90 days The rapidly dividing cartilage cells (N) are for the most part from the perichondrium of the recipient cartilage (H) while degenerated cartilage cells (D) can be seen on the border of the transplanted cartilage (G) Many of the new cartilage cells are bi- or multinucleated and irregularly arranged Six microns in thickness Harris's hematoxylin and eosin 60X

The junction between host and graft cartilages after 120 days is shown in Fig 4 There is nothing significantly different from this specimen and previously shown specimens in other figures except the formation of new bone which seems to be encroaching on an area of newly formed cartilage There are a number of small blood vessels in relation to the new bone, but in contrast to Fig 2 the new bone is not completely surrounded by dense fibrous connective tissue

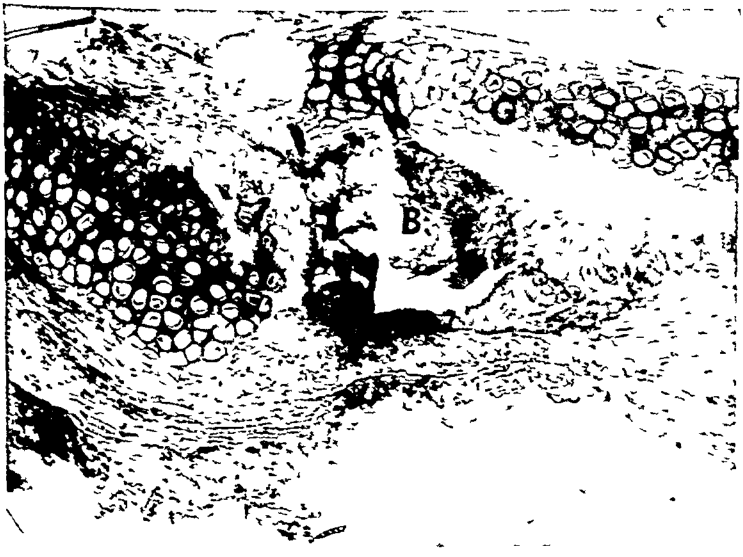

Fig 4 A photomicrograph of the union between graft (G) and host cartilages (H) after 120 days The cartilaginous union is being encroached upon by some new bone formation (B) which appears to be in a rather highly vascularized region Six microns in thickness Harris's hematoxylin and eosin 65X

A firm cartilaginous union between host and graft cartilages is apparent after 150 days and shown in Fig 5 The union is comprised of cells which are more mature than those in the preceding figures, but the matrix stains less intensely than that of the host and graft cartilages

V DISCUSSION

The results presented show that in the external ear of the experimental animals cartilaginous union occurs between the graft and host cartilage when the borders of each are closely approximated

It is well established that autogenous cartilage grafts retain their viability The early writers, Bert and Prudden, and the later studies of Loeb, Dupertius, Peer, and others have proven conclusively that autogenous cartilage does live after transplantation In the present study the viability of the grafts was definitely established Macroscopically the grafts retained their normal appearance and elasticity Macroscopically *the cartilage cells retained their* nuclei, matrix, and typical structure

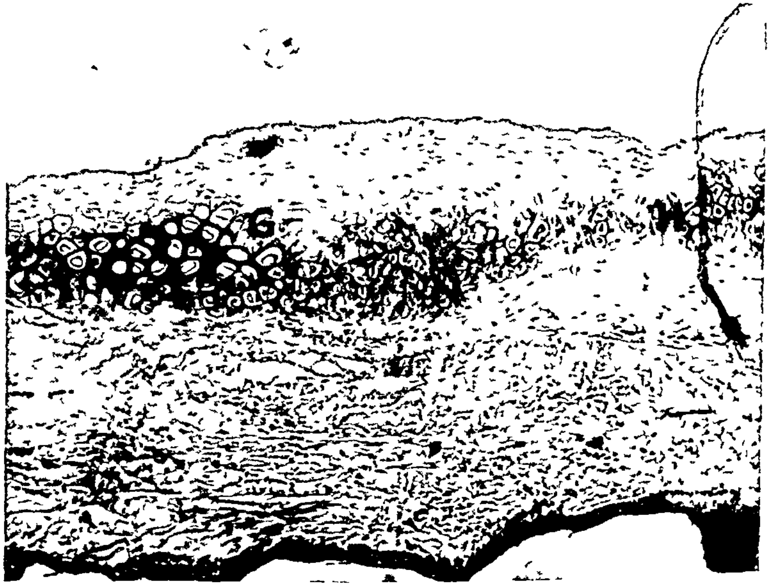

Fig 5 A photomicrograph of the cartilaginous union between the graft (G) and host cartilages (H) after 150 days The new cartilage cells (N) have some semblance of arrangement with more matrix intervening between the cells although the cartilage is still immature Six microns in thickness Harris's hematoxylin and eosin 65X

The work of Young, Dupertius, and Peer has proven that the presence of attached perichondrium is not necessary for the survival of the autogenous cartilage graft In the present work, the attached perichondrium was required to complete the experiment, and hence no comparison can be made

In this study, no measurements, were taken following the removal of the graft and, therefore, no data is available concerning the quantitive growth of the cartilage It has been pointed out, however, that there was no shrinkage of the graft, and in the 120-day and 150-day specimens it was impossible to determine the exact site of contact between the graft and the host area by macroscopic means Dupertuis and Peer have already demonstrated that young cartilage cells have the ability to grow following transplantation

The work of Laskin and Sarnat, with the respiration and anaerobic glycolysis of transplanted cartilage sheds much light on the factors involved in the viability of cartilage grafts They demonstrated that the low metabolic rate and the largely anaerobic metabolism of cartilage grafts permits the tolerance of the hypoxic states during the early period of transplantation

The present study is in complete agreement with the findings of Loeb Very little lymphocytic reaction was produced and there was no evidence of any foreign body reaction surrounding the cartilage grafts This indicates again that autogenous cartilage grafts evoke very little cellular response and also attests to the lack of sepsis in the wound area

It is interesting to speculate concerning the origin and formation of new bone which occurred in two of the specimens Clark and Clark found, in the transparent chamber of the rabbit's ear a similar development of new bone in the midst of an area of new cartilage It is possible that a slight change of unknown origin in the stimulus of the substance forming new cartilage may account for the formation of the new bone

Young found that finely chopped particles of cartilage embedded in the abdominal wall became adherent by fibrous union Brown has stated that autogenous cartilage grafts retain their integrity, but there was no statement concerning the specific type of union that occurs between the graft and its host area Peer and Walker state that cartilage transplants in the human are joined to the host cartilage by fibrous union and not by cartilaginous union There is no question that the specimens obtained in this study are joined firmly graft and host cartilage when the borders of each are closely approximated

It is well established that autogenous cartilage grafts retain their viability The early writers, Bert and Prudden, and the later studies of Loeb, Dupertius, Peer, and others have proven conclusively that autogenous cartilage does live after transplantation In the present study the viability of the grafts was definitely established Macroscopically the grafts retained their normal appearance and elasticity Macroscopically the cartilage cells retained their nuclei, matrix, and typical structure

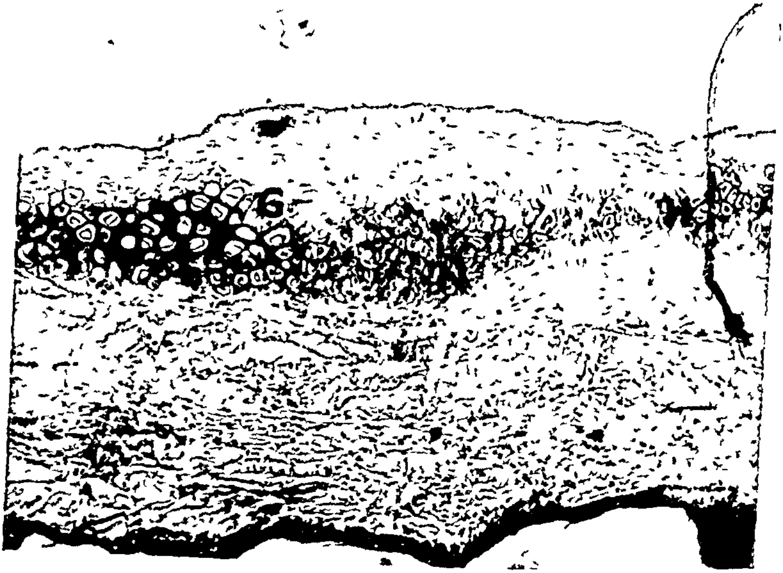

Fig 5 A photomicrograph of the cartilaginous union between the graft (G) and host cartilages (H) after 150 days The new cartilage cells (N) have some semblance of arrangement with more matrix intervening between the cells although the cartilage is still immature Six microns in thickness Harris's hematoxylin and eosin 65X

The work of Young, Dupertius, and Peer has proven that the presence of attached perichondrium is not necessary for the survival of the autogenous cartilage graft In the present work, the attached perichondrium was required to complete the experiment, and hence no comparison can be made

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and closely as determined both macroscopically and microscopically It is probable that this cartilaginous union was obtained because of the care taken to insure exact approximation between the host and the graft There is no doubt that the presence of an intact perichondrium and established blood supply of the host area have contributed to and hastened the union A careful review of the literature reveals no experimentation which is identical to this particular study

VI CONCLUSIONS

1 Cartilaginous union between the graft and host cartilage occurred

2 Small areas of bone formation occurred to some extent in two of the specimens (60 days and 120 days) at the point of union

3 The perichondrium of the host cartilage proliferates and produces new cartilage which is underway in 30 days

4 The perichondrium of the graft is also active, but less so, at the point of union with the host cartilage

5 The older cartilage cells at the border of the graft appear to undergo degenerative changes with encroachment of the newly formed cartilage

6 The remainder of the cells of the graft retain their viability, and at 150 days there was no evidence of a replacement over a 90-day specimen

7 It is possible that the cell degeneration at the periphery of the graft may be due to tissue injury while the cells more centrally located maintain their integrity

8 Vascularity was found to be moderate in the areas of the ears from which the grafts were taken and also transplanted In the early stages there was some proliferation of fibrous tissue and small blood vessels into the region of contact of the graft with the host area, following this, perichondrial cells were seen to proliferate and new cartilage formation occurred In the rapidly forming areas of new cartilage, binucleated cells were markedly in evidence

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PAN-PACIFIC SURGICAL ASSOCIATION

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Routine laboratory examinations were essentially negative

A tentative diagnosis was made of bronchiectasis and neoplasm of the right main stem bronchus at the terminal end

Roentgenologic examination of the chest Feb 4 1951 showed a rather marked patchy emphysema throughout both lung fields There was an area of increased density in the right cardiophrenic angle which the radiologist considered due to a bronchiectasis, though he noted that the presence of a rather smooth area of increased density in the hilar portion of this lung made it necessary also to consider the possibility of a malignant tumor

Examination of the larynx and trachea Feb 9 with air as a contrast medium showed a definite narrowing of the trachea just below its opening from the larynx The impression was that some type of mass was present on the posterior wall of the trachea, and direct visualization of the area was suggested as likely to be more useful than films

Examination of the esophagus with barium Feb 14 showed it to be normal in all views

Feb 7 the 9 mm Jackson bronchoscope was easily passed for a distance of 21 cm from the upper incisor teeth At this point a hard polypoid pedunculated, broad based lesion was observed on the right posterolateral wall Upon expiration, the lesion practically occluded the entire lumen of the trachea On inspiration it swung down against the tracheal wall and there was no respiratory difficulty as there was on expiration A specimen was secured from a suspicious looking granulating area in the lesion, there was no bleeding

When the main stem bronchus was entered, the mucous membrane was found to be extremely edematous and hyperemic and a large amount of purulent material was aspirated, but no tumor was noted The left main stem bronchus revealed hyperemia of the mucous membrane and a moderate amount of purulent material

The prebronchoscopic clinical diagnosis of bronchogenic carcinoma and bronchiectasis was changed to fibroadenoma of the trachea and right bronchiectasis

The pathologic report and histologic diagnosis was chronic bronchitis, probable squamous metaplasia of the trachea, bronchial exudate with squamous cells but no evidence of any malignant change The findings were regarded as inconclusive and a second biopsy was recommended

Bronchoscopy was repeated Feb 12 1951 The bronchoscope was passed until the tumor mass previously described was encountered It extended downward for several tracheal rings and practically obstructed the entire tracheal lumen except for the anterior portion The postbronchoscopic diagnosis was again adenoma of the trachea The specimens which were secured with only minimal bleeding were reported by the pathologist as one of the very uncommon benign fibromas of the trachea It was not possible to determine from the specimens whether the tumor was uniformly fibrous throughout or might contain mixed elements or even cartilage

During his first few days in the hospital the patient continued to cough and to present all the signs of a respiratory obstruction He could not lie down in bed and had to sleep sitting up though with medication it was possible most of the time to secure adequate rest and sleep for him

Operation was performed Feb 15 1951, under general anesthesia administered by the endotracheal technique on the diagnosis of fibroma of the trachea

HAMARTOMA OF THE TRACHEA

Report of a Case, with a Review of the Literature of Benign Tracheal Neoplasms

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San Angelo, Tex

The trachea, which is the segment of the respiratory pathway between the larynx and the main bronchi of the lung, is distinguished from these structures in a number of ways, most notably by its peculiar immunity to tumor formation The incidence of bronchogenic malignant tumors has increased enormously in the past several years, but no similar increase has been noted in the incidence of tumors of the trachea The number of tracheal tumors on record in the literature is, in fact, so limited that reports of individual cases of the rarer neoplasms are still justified

CASE REPORT

A 51 year old white man was first seen Feb 3, 1951, with the chief complaint of asthma This diagnosis, he stated, had been made by a number of physicians whom he had previously consulted

The patient had what he described as "throat trouble" off and on for the past 20 years, and for the last several years he had had progressively increasing difficulty in breathing, more marked when he had a cold He also had some shortness of breath on exertion, and for some time had been unable to sleep recumbent He had a severe cough, which was more pronounced in the recumbent position, and a moderate amount of mucopurulent sputum, which at times seemd to contain considerable pus but which had never been bloody There was no pain in the chest, except after severe coughing spells, and no history of loss of weight

When the patient was first seen, his breathing was noisy and obviously difficult Examination of the chest, however, failed to disclose asthmatic sounds, and the findings were much more suggestive of obstruction somewhere in the trachea or in one of the bronchi than of asthma

Examination of the ears, nose and throat was negative There was normal movement of both the true and the false cords on phonation and respiration

Although breathing was labored chest expansion was normal bilaterally Crepitant rales were heard over the lower right side of the chest Elsewhere, the breath sounds were normal except that they were somewhat noisy because of an apparent mechanical obstruction in the trachea or the bronchi

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Editor's Note This manuscript received at The Laryngoscope Office and accepted for publication Feb 15 1959

The patient was observed at weekly intervals for the next three weeks He had no complaints except for some cough and continued foul sputum attributable to bronchiectasis He returned to work April 1 and when he was examined April 14, he was in excellent condition and had no complaints When he was readmitted to the hospital June 9 for a routine postoperative check-up he had no complaints of any kind Bronchoscopy showed no evidence of a residual tumor

The patient was observed at irregular intervals for four years after operation On his last examination, in June of 1955, he was 30 pounds heavier than when he was first seen He had no difficulties in breathing and no wheezing, regardless of his position, and he slept recumbent in complete comfort

FREQUENCY AND CLASSIFICATION

Tumors primary in the trachea, if not actually rare, are extremely infrequent in comparison with tumors of the larynx and bronchi

Holinger and his associates[1] report the frequency of tumors of the trachea as compared with tumors of the larynx ranges from 1 300 to 1 800 According to Broyles,[2] tumors of the lungs and trachea are five times more frequent in males than in females and are most often observed between the fourth and sixth decades

The collection of tracheal tumors recorded in the literature has grown slowly At the time of D'Aunoy and Zoeller's[4] comprehensive report in 1929, all recorded primary tracheal tumors numbered only 351

Benign tumors of the trachea, although infrequent, encompass a wide variety of pathologic types In D'Aunoy and Zoeller's[4] collected material, there were chondromas, osteomas, papillomas, fibromas, intratracheal goiters, adenoma and cylindroma

A comprehensive search of the literature has revealed no previous recorded instance of hamartoma of the trachea None of the five pathologists who examined the slides of the tumor reported in this communication had this type of tumor in their collection of pathologic material An inquiry of the Armed Forces Institute of Pathology produced the information that the single case in the files was an incidental finding at autopsy[11]

The differing points of view of several excellent pathol-

A midline tracheal incision was made from the thyroid cartilage over the cricoid cartilage and continued down in the midline of the neck to the sternal notch After the isthmus of the thyroid was divided in the center, the second, third and fourth tracheal rings were then incised

Examination of the trachea up to the glottic chink showed no abnormalities The distal portion was occluded by the neoplasm demonstrated on bronchoscopy

After the pleura was reflected from the trachea and the fifth, sixth, seventh, eighth and ninth tracheal rings were incised in the midline, the neoplasm was brought into view on the posterior right lateral wall of the trachea It was circular, nodular and broad based The color was grossly that of the normal tracheal mucosa

The mass was grasped with a tenaculum and with the tonsil snare wire but had to be removed by morcellation because the tonsil wire could not be placed over it in its entirety It was excised down to the level of normal mucosa of the trachea After the mass had been removed, the trachea was entirely patent, and the right main stem bronchus was also patent and unobstructed

The tracheal rings were closed with chromic 0 catgut A cigarette drain was placed into the superior mediastinum and the wound closed in the usual fashion After a No 6 tracheotomy tube of specially long construction, had been inserted into the trachea, the skin edges were approximated with 0 silk

The postoperative diagnosis was fibroma versus hamartoma of the trachea The pathologic report revealed the first specimen measured 1 5 cm in length while the second specimen, which consisted of the bulk of the tumor, weighed 6 grams

The findings most closely suggested hamartoma of the trachea, and this diagnosis, which at first tentative, was also the pathologist's final conclusion on the ground that the tumor was made up of superfluous normal tissue, and that more than one type of tissue was present

The slides in this case were sent to four other pathologists, of national reputation in Texas and elsewhere Two agreed with the diagnosis of hamartoma The third, while agreeing that the tumor was benign considered it a lipoma that had incorporated mucous and serous glands and smooth muscle of the trachea The fourth also considered it a benign lipoma, on the ground that the glands and some other elements in it *developed in the fat as the tumor protruded in polypoid fashion into the* lumen He added, however, that he would be the first to agree that the large amount of glandular tissue within the tumor was not easy to explain on the basis of simple incarceration in the course of extension of a lipoma into the tracheal lumen

The patient was in excellent condition at the end of the operation and breathed fairly well while still in the reclining position The usual postoperative routine was instituted

Emphysema of the neck appeared on the first postoperative day and extended to the occipital areas and down to the clavicle, it began to disappear within 48 hours The patient was up and about on the third postoperative day When the tracheotomy tube was removed on the fifth day, he breathed satisfactorily, with no evidence of the previous obstruction He stated that he had not felt so well in the past five years, and that this was the first time in that whole period that he had been able to sleep recumbent and really enjoy a night's rest The sutures were removed on the sixth postoperative day The patient was discharged from the hospital March 2 in glandular tissue[4] These tumors are most frequently located in the lower third and most infrequently in the middle third[5]

The etiology of benign tracheal tumors is unknown, though in most of them it is evident that inflammation, if it is not the primary factor, is an important secondary factor The inflammatory hyperplasia evident in the reported case is entirely typical

From the standpoint of origin, tracheal tumors are classified as endotracheal, murotracheal and peritracheal From the standpoint of location, they are classified as cervical and intrathoracic From the mechanical standpoint, they are classified as obstructive and non-obstructive

Practically all the symptoms and signs to which tumors of the trachea give rise can be explained on a mechanical basis

Dyspnea is usually the earliest and most prominent symptom It may be constant or paroxysmal, but is almost invariably worse at night Cough, which at first is dry and nonproductive, becomes productive later as the tumor increases in size Other symptoms include cough, fever, pain, hemoptysis, and expectoration, which is usually purulent and blood-tinged Clubbing of the fingers and toes is sometimes present, and abscess of the lung has occurred

Endotracheal tumors, as well as murotracheal and peritracheal growths, if their growth is not interrupted, will eventually obstruct the tracheal lumen because of their bulk or inward pressure

DIAGNOSIS

Wheezing, which is the outstanding symptom in bronchial tumors, may also be present in tracheal tumors Jackson,[8] in fact, considers that a wheeze heard at the open mouth which he calls the asthmatoid wheeze, is the most important of all symptoms It is best heard near the end of a forced expiration and is characteristically increased by exertion

On the other hand, as Jackson has also correctly pointed out, everything that causes a wheeze is not asthma My own ogists in the case recorded herewith are apparently entirely typical of tumors of the trachea, which seem to present more pathologic than clinical difficulties According to Jackson and Jackson,[9] whose remarks were made in connection with adenomas of the trachea, if sections of these tumors should be submitted to various pathologists, some sections would still be classified as adenomas, but others would be reclassified as inflammatory tissue The differences of opinion, continued these observers, would be no criticism of the histologists, but would, on the contrary, simply emphasize the difficulties of histologic diagnosis and the importance of the inflammatory processes that result from bronchial or tracheal obstruction

Smith's[12] report of an adenoma is an excellent illustration of how sound pathologists may disagree about these tumors The tumor which was removed by the external approach, from the trachea, was diagnosed by his own pathologist as a benign tumor of the bronchial type When, however, the specimen was examined by five other experienced pathologists, it was variously diagnosed as *1* a benign bronchial adenoma, likely to recur, *2* adenocarcinoma, *3* adenocarcinoma arising from the minor salivary glands, *4* a benign mixed tumor, and *5* an aberrant tumor of the thyroid gland without evidence of malignancy Whatever the correct histologic diagnosis might be, the condition was benign, for the patient, as in my own case, was alive and well at the end of five years

Jackson[8] makes the excellent practical point that while histologically all tumors of the trachea can be placed in either the benign or the malignant group, some benign growths may, in effect, be malignant, in that they can kill the patient Benign may be used in its conventional sense and for the sake of simplicity, but, he continues, a growth that causes death is not benign in the strictest meaning of the term Death from asphyxia would certainly have occurred in my own case if the condition had not been relieved, the mechanical proof of that possibility was demonstrated at bronchoscopy

PATHOLOGIC PROCESS AND PATHOLOGIC PHYSIOLOGY

As in this case, tumors of the trachea are most frequently located on the posterior tracheal wall, which is far richer in glandular tissue[4] These tumors are most frequently located in the lower third and most infrequently in the middle third[5]

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On the other hand, as Jackson has also correctly pointed out, everything that causes a wheeze is not asthma My own case well illustrates this point, the patient was treated for asthma for five years Obstruction of the trachea causes a clinicopathologic syndrome which so closely resembles true asthma that every instance of clinical asthma should be studied for evidence of tracheobronchial disease In Jackson's[6] own series, every tracheal or bronchial tumor which did not cause external bulging was mistaken for asthma because the patient had a wheeze Since tumors of the trachea frequently grow slowly, a tracheal tumor may be present for years before its true nature is recognized

A tentative diagnosis of tracheal tumor can be made from the history, physical examination and radiologic studies, but the presence or absence of a tracheal tumor, like the presence or absence of a bronchial tumor, can be confirmed or ruled out only by bronchoscopy Examination under the fluoroscope with lipiodol, followed by roentgenologic examination, is of supplemental usefulness, but bronchoscopy followed by biopsy is the only conclusive diagnostic method

In infants and children, the differential diagnosis of tracheal tumors includes laryngismus, stridulus and papilloma of the larynx In adults, chronic tracheitis and chronic bronchitis may cloud the issue, but the great pitfall, as in the reported case, is asthma

TREATMENT

The diagnosis of a tumor of the trachea serves, *per se*, as an indication for its removal, since, as in my own case, even a benign tumor may so encroach upon the airway as eventually to cause serious symptoms

If the tumor is small, it can usually be removed by bronchoscopic methods, either *in toto* or by morcellation Jackson[6] warns against attempted control by radiotherapy, because of the extensive dosage required and the possible risk of subsequent perichondritis and chondronecrosis

If, as in the case of hamartoma, the tumor is too large to be removed through the bronchoscope, it will be necessary to use the external approach Excision should extend for several millimeters beyond the evident limits of the tumor

If the excision is so extensive that closure of the trachea is impossible after the tumor is removed, some prosthetic device may be employed as recommended by Belsey[1] and by Clagett and his group.[3] This group utilized a polyethylene tube.

In summary, benign tumors of the trachea are extremely infrequent. To date, less than 550 have been reported. A wide variety of pathologic types is represented in the reported cases, but pathologists are frequently in disagreement concerning the histologic diagnosis. Classification into benign and malignant types is always possible, but a benign neoplasm may have malignant potentialities, in that, if not removed surgically, it may kill the patient by completely blocking the airway.

All benign tumors of the trachea, regardless of pathologic type, present much the same symptoms and signs, practically all of which may be explained on a mechanical basis. Diagnosis may be suspected clinically and roentgenologic examination is of supplemental usefulness, but a precise diagnosis is possible only by bronchoscopy and biopsy. Bronchial asthma is the chief diagnostic pitfall; the possibility of a tracheal tumor must be borne in mind in very case in which an asthmatoid wheeze is present.

All tracheal tumors must be removed; their mere presence is an indication for their excision by bronchoscopy if they are small enough to permit this technique, otherwise by intratracheal surgery.

The case of hamartoma reported in his communication bears out practically all of these generalizations. It is apparently the first case of the kind to be recorded in the literature.

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SECOND WESTERN REGIONAL MEETING OF THE INTERNATIONAL COLLEGE OF SURGEONS

The second Western regional meeting of the International College of Surgeons is to be held in Las Vegas this November. Registration will be Sunday, November 22, Scientific Meeting, Monday and Tuesday, November 23 and 24, at the Stardust Hotel. Registration fee, $35.00—including banquet and cocktails. (There is no registration fee for interns and residents.) Hotel reservations are to be made directly to the hotel. For further information concerning this meeting, contact Dr. F. M. Turnbull, Jr., 1930 Wilshire Blvd., Los Angeles 57, Calif.

CERVICAL SYMPATHETIC PARALYSIS*†

WARREN E. WIESINGER, M.D.,
Oakland, Calif.

The cervical sympathetic pathway may be involved in a variety of lesions. These may be central, involving the brain or spinal cord, or peripheral, interrupting the fibers on their way to the organs supplied. In reviewing this subject, evidence will be presented that the pathway for the oculopupillary fibers is through the tympanum. Pathological entities which may produce cervical sympathetic paralysis will be discussed, along with tests for the localization of the level of the lesion in Horner's Syndrome. An awareness of the proximity of the sympathetic nerves and ganglia may serve to avoid their severance, or, if this is not possible, to warn the patient of the sequelae.

Interruption of the cervical sympathetic pathway results in miosis, ptosis, enophthalmos, anhidrosis and vascular hyperemia. This syndrome carries the name of Horner,[1] who described it in 1869. Prior descriptions have been credited to Claude Bernard, Remak and Weir, Mitchell, Morehouse and Keen[2]; nevertheless, Horner's name is tightly bound to the syndrome, and acceptance of the association is universal.

The miosis results from paralysis of the dilator pupillary muscle supplied by the post-ganglionic fibers from the superior cervical ganglion. Ptosis results from paralysis of the superior tarsal muscle of Muller. The enophthalmos is not fully understood; it is the opinion of many ophthalmologists that the slightly sunken appearance is due to drooping of the upper lid and is not a true enophthalmos. Others have ascribed it to paralysis of the orbital muscle of Muller, a band of smooth muscle in the floor of the orbit, whose contraction supposedly

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causes a slight protrusion of the eyeball[3] This muscle action is so slight that it is doubtful that its loss could account for the appearance of the eye as seen in Horner's Syndrome The vasodilatation and dryness of the skin of the face are due to damage to the vasoconstrictor and sudomotor fibers which pass through the cervical trunk

ANATOMY

The pathway of the sympathetic outflow from the brain to the eye is a circuitous one, allowing opportunity for lesions in many locations to interrupt its action Experimental work indicates that there is a pathway from the frontal lobe to the hypothalamus[4] From here the fibers pass down the brain stem to end in the upper portion of the lateral sympathetic nucleus of the spinal cord The preganglionic fibers originate here to end in the ganglia of the sympathetic trunks The latter are two cords situated along the lateral aspect of the vertebrae, extending from the base of the skull to the coccyx

The cervical portion of the trunk contains three ganglia, probably formed by the fusion of the originally segmental ganglia The superior cervical ganglion is situated near the second and third vertebrae It is the largest The middle is near the sixth cervical vertebra The inferior is situated near the seventh cervical vertebra and is frequently fused with the first thoracic ganglion to form the stellate ganglion There is segmental arrangement in the thoracic, lumbar, and sacral regions The preganglionic fibers, originating in the lateral sympathetic nucleus, are customarily described as passing by way of the white rami communicantes to the ganglia Palumbo,[5] however, believes that the pupillo-ciliary fibers are an exception, because, in 95 per cent of his cases of upper thoracic sympathectomy, division of the first thoracic ramus and adjoining rami, and removal of the lower third of the stellate ganglion, did not result in Horner's Syndrome It is his opinion that the pupillo-ciliary fibers reach the upper part of the stellate gangion by a separate paravertebral route The cervical ganglia receive ascending fibers from the VIIIth cervical and upper thoracic nerves, most of the fibers going to the superior cervical ganglion The post-ganglionic fibers arising from the ganglia are distributed as grey rami communicantes to the adjacent cranial nerves (IXth, Xth, and XIIth), to the upper three or four cranial nerves, to the pharynx, and to the external and internal carotid arteries, around which they form plexuses From these plexuses, fibers supply the dilator muscle of the iris, the smooth muscle portion of the levator palpebrae, the orbital muscle of Muller, the blood vessels, sweat glands and hairs of the head and face, and the lacrimal and salivary glands

The pathway of the post-ganglionic fibers from the superior cervical ganglion to the pupil is usually described as leading from the plexus on the internal carotid artery, without deviation to the cavernous plexus Kunz[6] states that the cells in the superior cervical ganglion send fibers via the internal carotid plexus, the ophthalmic, the nasociliary, and the long and short ciliary nerves to the radial muscle of the iris Duke-Elder[7] describe the route as from the superior cervical ganglion to the carotid plexus, to the cavernous plexus, then to travel over the Gasserian ganglion along the first division of the Vth nerve, continuing with the nasociliary nerve and then with the long ciliary nerves, entering the globe with the long ciliary arteries (some, perhaps, running without a relay along the long and/or sympathetic root of the ciliary ganglion to the short ciliary nerves), traversing the epichoroidal space to reach the iris and terminate in the dilator muscle Craig and Fuller,[8] and Bedrossian[9] are in agreement with Kunz and Duke-Elder

A review of the literature reveals only one reference to a pathway of the oculo-pupillary fibers through the middle ear Hubert,[10] in reporting a Horner's Syndrome following radical mastoidectomy, mentions that several filaments from the carotid sympathetic detach themselves and penetrate the middle ear cavity while traversing the anterior wall He further states that they travel to the anterior part of the promontory underneath the mucous membrane, and sometimes in the depth of the bone of the anterior wall, to the petrosa The sympathetic filaments coming from the carotid plexus and traversing the tympanum are then described as rejoining the plexus to reach the dilator muscle of the pupil finally by causes a slight protrusion of the eyeball[3] This muscle action is so slight that it is doubtful that its loss could account for the appearance of the eye as seen in Horner's Syndrome The vasodilatation and dryness of the skin of the face are due to damage to the vasoconstrictor and sudomotor fibers which pass through the cervical trunk

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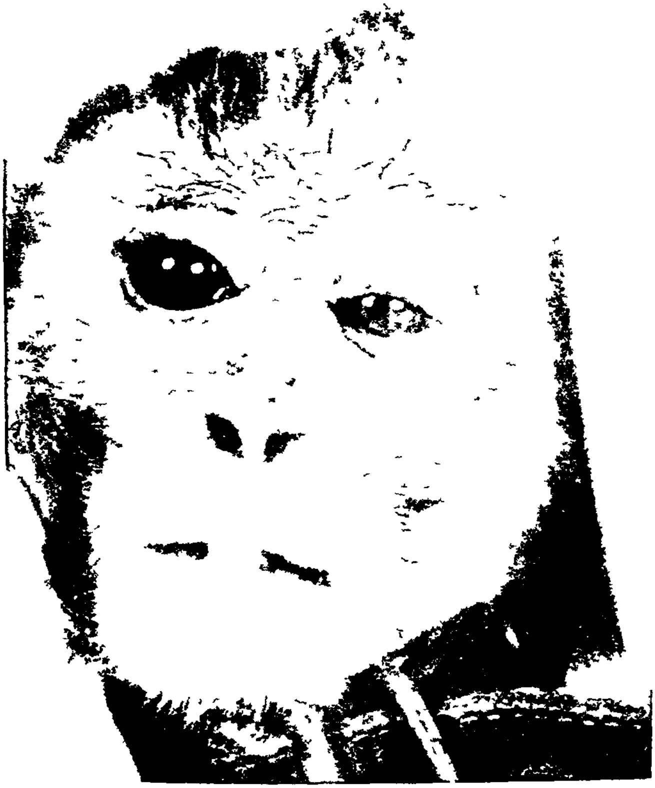

Fig 1 The picture above demonstrates appearance after interruption of the superior carotico-tympanic branches on the left side Note the ptosis and appearance of enophthalmos in the left eye Miosis is not well demonstrated because the pupils are constricted due to the strong light

branches, and that the location of the dilator pupillary fibers is high on the mesial wall of the middle ear

It is conceded that the rarity of Horner's Syndrome following radical mastoidectomy militates against the superior carotico-tympanic pathway for the oculo-pupillary fibers, inasmuch as it would be expected that paralysis would often follow operations in this area, however, it must be emphasized that the nerves are situated in grooves in the bone and are, therefore, protected against injury during the usual careful removal of mucous membrane and granulation tissue It accompanying branches of the long ciliary nerves This pathway for the dilator fibers is considered rare by Hubert, for he states that the majority, and sometimes all, of the sympathetic ocular fibers continue along the carotid plexus without entering the middle ear cavity Hubert, in his description of the branches which penetrate the petrosa from the middle ear, is obviously referring to the superior carotico-tympanic (small, deep petrosal) nerves Morris[11] describes this connection of the tympanic plexus with the cavernous plexus through the superior carotico-tympanic branches, but makes no mention of function Raeder,[12] in his discussion of the ramifications of the internal carotid plexus, referred to the probability of some fibers passing by way of the deep petrosal nerve to the sphenopalatine ganglion to innervate the orbital muscle, but did not assign pupillo-dilatation to this pathway

By investigating the tympanic plexus (in the monkey), I was able to demonstrate the route of the pupillo-dilatory fibers from the superior cervical ganglion through the middle ear, via the superior carotico-tympanic branches First, the superior cervical ganglion on the posterior aspect of the carotid sheath was identified Stimulation of the ganglion resulted in dilatation of the pupil on that side The ganglion was then cut and loss of dilatation of the pupil on that side was noted when painful stimuli were given On the opposite side, the promontory of the middle ear was exposed through an endaural radical mastoidectomy approach The mucoperiosteum of the promontory was scarified and the endaural incision closed No effect was seen on the pupil This procedure was repeated on a second monkey, and no effect was noticed On a third monkey, after first ascertaining that normal pupillary responses were present, particular attention was given to the region just below the semi-canal and cochleariform process, but above and slightly anterior to the promontory, in the scarification Immediately after recovery from anesthesia, it was apparent that a miosis was present It is obvious from the photographs of the monkey, that ptosis and the appearance of enophthalmos is present, as well as miosis (see Figs 1 and 2) The oculo-pupillary paralysis persisted It was, therefore, demonstrated that the pathway of the dilator pupillary fibers is through the superior carotico-tympanic to assume that the route, proven by the experiment in the monkey, is only an occasional one

ETIOLOGY

From the description of the neuro-anatomy involved, it is evident that a Horner's Syndrome may be produced by lesions in the brain, spinal cord, thorax, neck, and in the cranium

Central lesions include thrombosis of the posterior inferior cerebellar artery, syringobulbia, syringomyelia, tumors of the cervical region of the spinal cord, and injuries in these regions Kendall[13] emphasizes that the syndrome is not an isolated phenomenon, but a part of the complete neurological findings produced by these lesions

Peripheral lesions involve pre- or post-ganglionic fibers, therefore, any lesion capable of producing interruption of these fibers, from the spinal cord to the termination of the post-ganglionic fiber, must be considered

Egbert[14] reported a case following left lumbar paravertebral block at the level of L-I and L-II for relief of phlebitis in an 18-year-old female, 10 ml of procaine was injected at each level Spontaneous recovery was present in one-and-a-half hours This case demonstrates the possibility of production of a Horner's Syndrome by diffusion of anesthetic solution through facial planes, even though the site of injection is remote

DeJong[15] reported ten cases in which Horner's Syndrome was part of the findings on physical examination The vulnerability of the sympathetic system to varying etiological factors in widely separated areas is well shown in his presentation Horner's Syndrome was observed in a tumor of the spinal cord, syringomyelia, cervical pachymeningitis, aortic aneurysm, tumor of the upper part of the pulmonary sulcus, metastatic mammary carcinoma, and complicating thyroidectomy and phrenicotomy

Intrathoracic lesions such as lymphosarcoma, Hodgkin's, bronchogenic carcinoma, esophageal carcinoma, and trau-

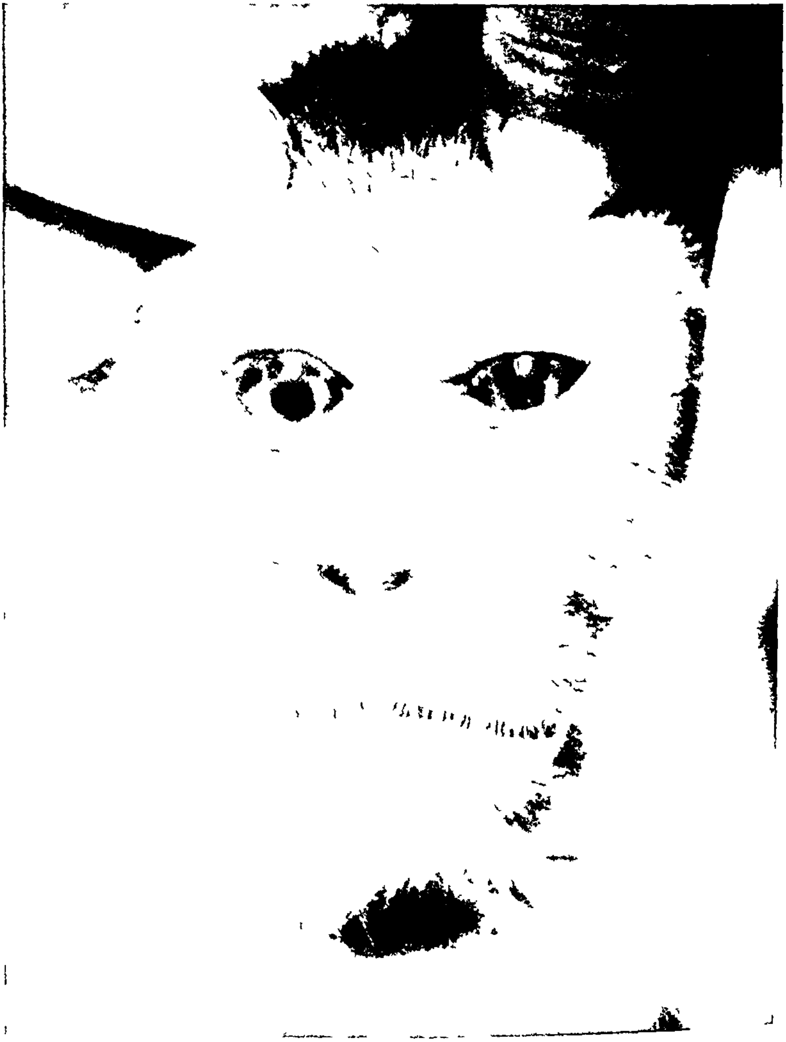

Fig 3 A painful stimulus (pin-prick) is being applied The right pupil is widely dilated as compared to the left The superior carotico-tympanic fibers have been interrupted on the left side

required actual notching of the bone with a sharp elevator to interrupt their continuity This type of deep scarification is not part of the usual technique of radical mastoidectomy The protection of the grooved bone in an area where rough instrumentation is hazardous can account for the "surgical immunity" of these branches, therefore, it is not necessary

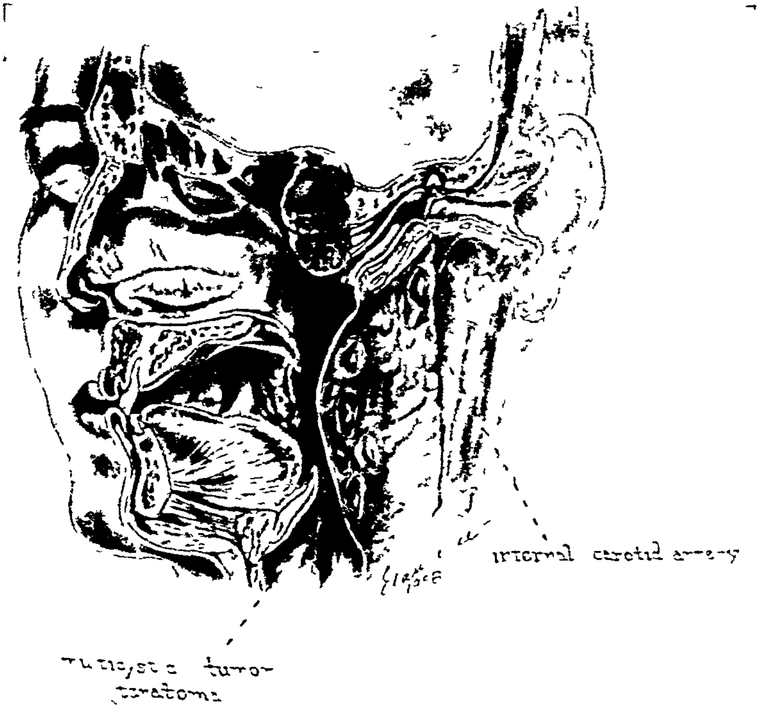

Fig 3 The drawing is reproduced from Jackson and Jackson Diseases of the Nose Throat and Ear Fig 231 page 287 published by W B Saunders Co 1945 and is adapted to show teratoma by E Lawrence

of content at the present time The surrounding tissue is soft and spongy The microscopic sections show multicystic lesions with the cysts lined by cuboidal flattened and columnar epithelium There are a few areas showing metaplasia Scattered throughout are areas of lipoid granulation tissue with fatty acid crystals old blood pigment and proliferating fibroblasts The main mass is composed of thymic tissue with characteristic thymic lobules primary and secondary and characteristic Hassell s Corpuscles Diagnosis cystic teratoma ’

After a febrile postoperative period the patient was discharged from the hospital On the first postoperative office visit a week later the mother inquired as to why the left pupil was so large as compared to the right Examination revealed paralytic miosis of the right eye

The injury to the sympathetic pathway in this patient was undobtedly done in dissecting free the superior lateral pole of the tumor The damage was to the superior cervical ganglion itself, none, I am thankful to say, to the internal carotid artery !

matic lesions such as gun shot wounds and knife wounds, may also produce the syndrome

Pancoast[16] reported seven cases of a "superior sulcus" tumor in the upper part of the pulmonary sulcus in which Horner's Syndrome accompanied pain in the VIIIth cervical and first thoracic trunk distribution, and wasting of the muscles of the hand On X-ray examination, this tumor showed a typically small, sharply defined shadow in the apex of the thorax with destruction of one or all of the upper three ribs and the adjacent transverse processes and, sometimes, slight vertebral body erosion The specificity of this tumor has been doubted because the so-called "Pancoast Syndrome" is common to all sorts of lesions in this area

In the neck, a large variety of lesions may be causative Horner's Syndrome has been observed in traumatic wounds, thyroid adenoma,[17] in metastatic carcinomatous nodes and neurogenous tumors[18] Weir Mitchell, Morehouse and Keen, in 1863, six years prior to Horner's description of the syndrome, gave a detailed observation of the clinical picture in a gun shot wound suffered by a Civil War soldier[19] They correctly attributed the cause to the interruption of the cervical sympathetic nerves

Operative procedures on the posterior pharyngeal wall in its lateral aspect may damage the internal carotid plexus, as shown in the following case

G S, aged ten, was seen on Nov 29, 1952 because of difficulty in swallowing of two months' duration The past medical history was not relevant There was no history of tuberculosis or other serious medical illnesses

Examination revealed a smooth mass extending from the level just above the soft palate downward to the hypopharynx and ending just above the level of the arytenoid cartilages The main mass of the tumor was slightly more to the right of the midline A chocolate colored fluid was removed by aspiration This had the appearance of old blood (see Fig 3)

Removal of the tumor was accomplished under general anesthesia A midline incision was made through the posterior pharyngeal wall and the tumor was removed by dissection blunt and sharp Dissection was slightly more difficult from the right upper lateral surface

The pathological report read as follows The submitted specimen consists of a lobular irregular shaped mass of tissue measuring 5x3x2 5 cm in size One pole appears hemorrhagic and on section there are several cysts ranging from 5 mm to 2 cm in diameter These are devoid its component neurons for the purpose of description of the action of drugs on the pupil at different levels The fiber from the hypothalamus to the cervical portion of the cord at the level of the VIIIth cervical and first thoracic is called the first neuron The second neuron (pre-ganglionic) ascends in the neck through the inferior and middle ganglia to the superior cervical ganglion The third neuron arises from the superior cervical ganglion and is distributed to the plexuses intracranially, as previously described [23]

The drugs employed in the pharmaco-dynamic tests are the parasympathetic depressants (atropine, homatropine, and their relatives), the parasympathetic stimulants (pilocarpine principally), and the sympathetic stimulants (cocaine and adrenalin) [24]

The action of epinephrine and cocaine on the pupil aid considerably in placing the lesion in the neuron involved Epinephrine has no effect on the normal pupil, however, if the post-ganglionic fibers are interrupted, there will be dilatation of the pupil on administration of epinephrine This is explained by the fact that when smooth muscle is deprived of its nerve supply it becomes hypersensitive to stimuli which normally mediate its action,[25] thus, the dilator fibers become sensitized, and minimal amounts of epinephrine will evoke a maximal response If the lesion is central (first neuron), or preganglionic (second neuron), there will be no dilatation with epinephrine, cocaine, on the other hand, causes dilatation in the normal pupil In lesions of the second or third neuron it will have no effect, but, for an unexplained reason, it will cause dilatation in lesions of the first neuron In an oculo-pupillary paralysis due to a thoracic or cervical lesion, or one along the internal carotid artery, the pupil does not dilate in response to cocaine

Pilocarpine injected subcutaneously (5 mg) will render the miotic pupil more constricted No sweating will occur on the affected side, while marked sweating will occur on the opposite side Pilocarpine is a parasympathetic ending stimulant which produces sweating by acting on the cholinergic post-ganglionic fibers of the sympathetic

Johnson and Fisher[20] reported a case following intra-oral removal of a Schwannoma They were able to find the superior cervical ganglion in the capsule of the tumor

Further reminder of the proximity of the sympathetic pathway to the oral cavity has been given by Hald and Goldtfredsen[21] reporting on transitory Horner's Syndrome after parasetonsillar anesthetization for local tonsillectomy They reported 11 cases of transitory paralysis, two of which were bilateral

Raeder[22] described involvement of the dilator pupillary fibers in the region of the Gasserian Ganglion Because of the coincidence of oculo-pupillary paralysis and trigeminal symptoms the location was described as "paratrigeminal" His first patient with this syndrome had headache, vomiting, pain in the left trigeminal area, paresis of the left side of the palate, paresis of the pterygoid muscles, epiphora, miosis, and hypotonia on the left side without vasomotor or trophic disturbances The patient died of tuberculosis, and postmortem examination revealed an endothelioma between the internal carotid artery and the Gasserian Ganglion He reported four other cases, two of which were the results of head injuries with probable skull fracture, one due to probable herpes zoster, and one, assumed to be a tumor, as in his first case

DIAGNOSIS OF THE LEVEL OF THE LESION

Localization of the level of the lesion relies on the clinical evaluation of signs and symptoms, and on the use of drugs to test the level at which the pathway is interrupted

Horner's Syndrome, in central lesions, is an incidental finding in the neurological picture produced by the lesion, localization will depend on the neurological findings accompanying the sympathetic paralysis In peripheral lesions, absence of sweating (anhidrosis) places the lesion at some place proximal to the external carotid plexus Conversely, in a Horner's Syndrome where sweating is present, the lesion is peripheral to where the external carotid plexus takes off from the main sympathetic trunk

It is convenient to divide the neuro-anatomical pathway into its component neurons for the purpose of description of the action of drugs on the pupil at different levels The fiber from the hypothalamus to the cervical portion of the cord at the level of the VIIIth cervical and first thoracic is called the first neuron The second neuron (pre-ganglionic) ascends in the neck through the inferior and middle ganglia to the superior cervical ganglion The third neuron arises from the superior cervical ganglion and is distributed to the plexuses intracranially, as previously described[23]

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DIFFERENTIAL DIAGNOSIS

The small pupil of a Horner's Syndrome (paralytic miosis) may be differentiated from a spastic miosis by the use of atropine and eserine In the presence of a dilator paralysis, atropine gives a relatively slight mydriasis, in a spastic miosis, atropine produces a considerable dilatation Eserine, in paralytic miosis, produces a maximal miosis, since the sphincter is completely unopposed In a spastic miosis it produces no effect as the sphincter is already in spasm

SUMMARY

1 The neuro-anatomy of Horner's Syndrome has been reviewed

2 Evidence has been presented that the pathway of the dilator pupillary fibers is through the superior carotico-tympanic branches

3 Pathological entities producing Horner's Syndrome have been presented

4 Localization of the level of Horner's Syndrome has been discussed

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PYOCYANEOUS OSTEOMYELITIS OF THE TEMPORAL BONE, MANDIBLE AND ZYGOMA*†

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The distinct pathologic entity, osteomyelitis of the temporal bone, infrequent in occurrence before the advent of chemotherapy and antibiotics, has all but disappeared today Even among the rare reports some must be weeded out, as they do not conform to the classic description first published by Toulmouche in 1838

The following case belongs unmistakably under this heading and presented some unusual features

Case History (Massachusetts Eye and Ear Infirmary, 92 65 28) A 61 year old man with severe diabetes was referred by Dr Louis G Lytton, of Miami, to Dr Meltzer on May 3, 1956, with the following history

The patient was first seen by his family physician because of pain in the right ear that developed in December, 1955, and grew worse Local treatment to the ear failed to relieve the pain, so he was referred to the otologist, Dr Lytton, on February 3, 1956 Examination revealed a markedly tender, edematous external auditory canal

For the next 11 days the patient was returned to the care of his family physician, during which time he received Combiotic twice daily for six days as well as local treatment to the inflamed ear The local swelling improved but the patient still complained of severe, right sided pain at night that required a narcotic for relief

On February 14, 1956, Dr Lytton found the nose and throat to be normal There was a pulsating, purulent discharge from the right external auditory canal with protrusion of granulation tissue Culture of the pus revealed Bacillus pyocyaneus, reported to be sensitive to Chloromycetin and streptomycin

Chloromycetin, in 250 milligram doses, was given every six hours for six days, without effect Then two grams of dihydrostreptomycin were given daily for a week, also without effect The symptoms of pain discharge, and preauricular and postauricular swelling persisted for two months, during which time five biopsies of the granulation tissue were

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reported to be pyogenic granulation tissue Repeated blood counts showed a moderate increase of the white cells but nothing else of importance

The blood sugar was difficult to control throughout this period, but the CO combining power was within normal limits, and the urine which occasionally revealed sugar, was always acetone and diacetic acid free

Roentgenographic examinations of the mastoids, including the petrous pyramids, were taken on February 16 and on March 24, 1956, and there was no evidence of any disease On April 4, destruction of the right mastoid was revealed for the first time on roentgenograms

On April 5, a right radical mastoidectomy was performed by Dr W Hotchkiss, Dr J F Hauss, and Dr L G Lytton Operation revealed marked softening of the mastoid cell partitions but no gross destruction or free pus The biopsy report was again "granulation tissue" Pyocyaneus was obtained from smears and cultures taken during the operation

The postoperative course was uneventful, except that there was a persistent purulent discharge from the cavity Because sensitivity tests indicated that the germ was sensitive to Chloromycetin, neomycin and Furadantin large doses of Chloromycetin were given intramuscularly from April 5 to April 14, without effect The pain, swelling and tenderness that extended over the right side of the face and over the zygoma were only temporarily relieved for the first five days after operation

On April 14, the patient left the hospital against advice, but was readmitted on April 25 because of the intense pain over the right side of the head, zygoma, and face A neurological consultant found no abnormalities Roentgenograms failed to disclose any disease of the petrous tip or zygoma The pyocyaneus was now sensitive to only neomycin and Furadantin and therefore neomycin, in 2 gram doses daily for five days and Furadantin in 100 milligram doses four times daily for five days were given, but without effect The patient wished to return to his permanent home near Boston, so he was referred to Dr Meltzer

May 3, 1956 The examination revealed marked swelling on the right side of the face, with tenderness over the zygomatic arch The mastoid cavity and the middle-ear space were completely obliterated by soft, pulpy granulations Pressure on the right lateral portion of the face caused considerable oozing of pus from the operative cavity The chief complaint was pain over the right side of the face and head The patient was admitted to the Massachusetts Eye and Ear Infirmary

May 4 Revision of right radical mastoidectomy The infected granulations were completely removed from the mastoid and middle ear The mastoid tegmen was removed, exposing a thin layer of granulation tissue over the dura The peritubal cells, including the tensor tympani muscle, were thoroughly exenterated No lead was found to account for the facial and zygomatic tenderness There was no subtemporal infection The posterior root of the zygomatic arch was explored and no infection was found

The revision failed to relieve the pain or to diminish the discharge

Miss A Mangiaracine the bacteriologist reported Bacillus pyocyaneous in pure culture not sensitive to any of the antibiotics that were previously used

May 15 An electroencephalogram was taken The report was "moderately abnormal right posterior temporal, parietal slowing"

May 16 Roentgenograms showed "left mastoid no destruction, right mastoid postoperative, petrous negative" There was no evidence of osteomyelitis

Right peripheral facial paralysis developed several days after the revision Examination of the fundi showed retinal vein engorgement Because of the continuing headache, increased tendon jerk at the biceps and wrist on the right, and a focal electroencephalographic abnormality, a lumbar puncture was performed, which was normal

June 5 Because pain and tenderness persisted over the zygoma and the right side of the face, and pus continued to well up in quantities that could not possibly arise from the mastoid cavity, reoperation was performed An abscess deep in the intratemporal fossa was suspected

Reoperation An endaural incision was made, between the helix and the tragus, extending over the temporal muscle, granulations were cleaned from the middle ear, and the anterior canal wall was removed, exposing the fascia of the temporomandibular joint A small fistulous lead was found, extending toward the zygomatic region When the fistula was dilated, a gush of pus flowed from a deep abscess A Miller Abbott tube was inserted into the abscess cavity The facial nerve was investigated and found to be intact The peripheral paralysis was due to edema of the sheath, evidently the result of osteitis The nerve was exposed and decompressed by slitting of the sheath

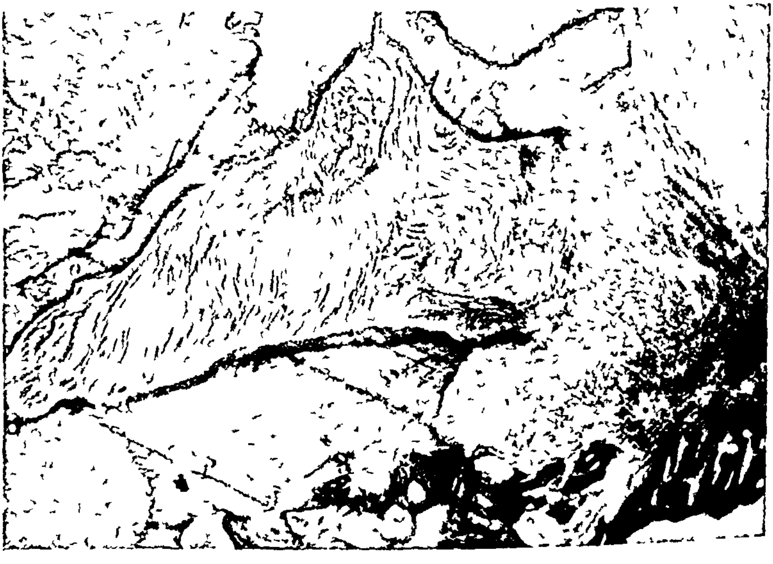


Fig 1 Bone destruction and regeneration with cholesteatoma particles in the middle ear (hematoxylin-eosin × 37)

June 9 A jugular foramen syndrome developed with paralysis of the right vocal cord, right palate and right pharyngeal wall, necessitating the introduction of a feeding tube Roentgenograms now revealed for the first time osteomyelitis of the right zygomatic bone and zygomatic arch

June 11 Stereoroentgenograms revealed for the first time decalcifica tion of the right petrous apex, with soft-tissue swelling in the vault of the pharynx

June 12 Neurological examination by Dr P R Dodge revealed extensive involvement of the cranial nerves at the base of the skull, secondary to osteomyelitis and extradural infection with the question of granuloma The cerebrospinal fluid findings on lumbar puncture with pressure on the jugular veins suggested thrombosis of the right internal jugular vein at the bulb or above which, it was believed would account for the electroencephalographic findings

Dr H Blotner the medical consultant, found the blood sugar, which occasionally rose to 315 mg per 100 ml extremely difficult to control during the entire hospitalization

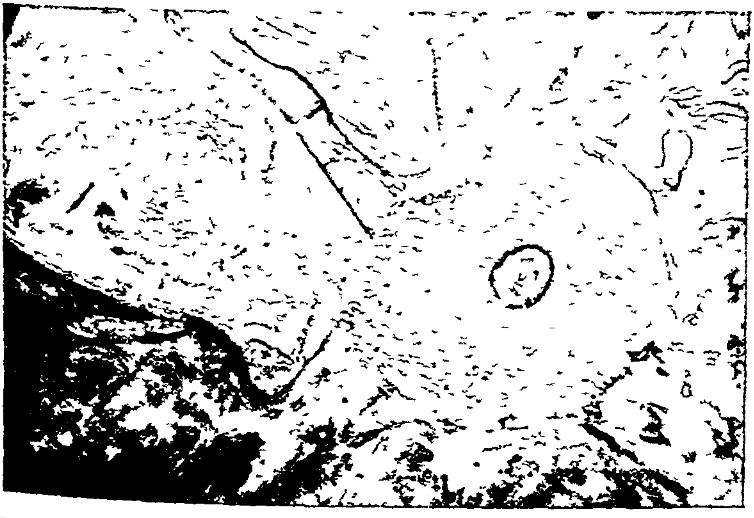


Fig 2 Suppuration breaks open and fills a peritympanic pneumatic cell destroying its walls (hematoxylin-eosin ×57)

By June 14 because of the persistent pain and swelling it was decided to remove the osteomyelitic bone and also the right ramus of the right mandible including the condyle and coronoid process in order to get direct treatment to the infected area in the region of the infratemporal fossa This decision was made after consultation with Dr G W Taylor for surgical opinion and Dr E H Kass for the bacteriological aspects of the problem

June 15 Dr Taylor ligated the external carotid artery and removed the parotid gland Dr Meltzer removed the ascending ramus of the mandible including the condyle and coronoid process the zygomatic arch and part of the zygomatic bone exposing a huge abscess lying on the pterygoid muscles The anterior and inferior external auditory canal walls were removed exposing the jugular bulb The petrous apex was entered by removing of the bone over the internal carotid artery as it traversed through the petrous apex Pain was relieved after this extensive procedure

The B pyocyaneus was reported to be sensitive to polymyxin and neomycin by Dr Kass's laboratory, therefore, iodoform gauze, soaked in *polymyxin and neomycin in ¼ of 1 per cent lactic acid solution*, was packed in the wound, this solution was changed three times a day In spite of the constant saturation of the field with these antibiotic solutions, culture from what appeared to be a clean cavity revealed luxuriant growth of *pyocyaneus When these antibiotics were tested against the organism* cultured at the Infirmary's laboratory by Miss Mangiaracine, however, they were completely ineffective

Following the operation of June 15, although there was no new evidence of systemic or local infection the patient's condition indicated that he was failing The condition of the local wound, however, was good The granulations appeared to be healthy *in spite* of the fact that there was an abundant growth of pure cutule of Bacillus pyocyaneus

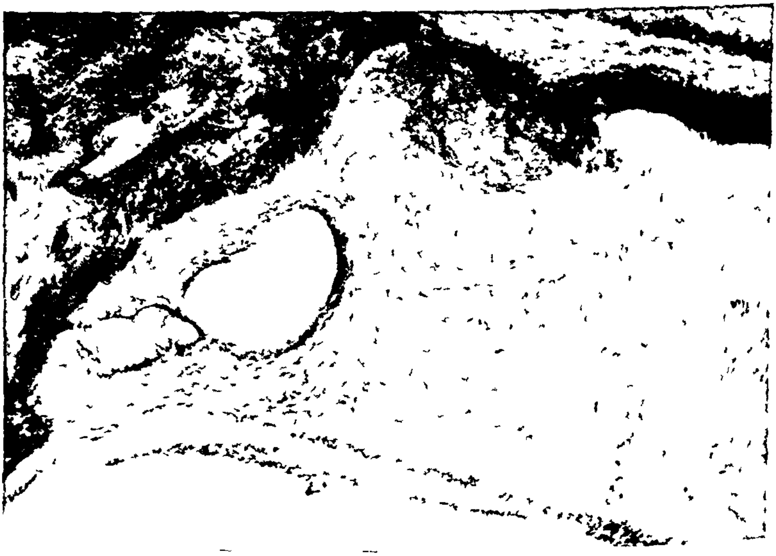


Fig 3 Callus repair of a facial-canal perforation (hematoxylin-eosin ×80)

July 13 On removing of the packs from the wound, the internal carotid artery was pulsating wildly, and the arterial wall ballooned out and ruptured The packing was immediately replaced Under general anesthesia an incision was made along the sternocleidomastoid muscle The carotid sheath was exposed, and the common carotid artery was clamped and tied The wound was examined, and a large hole in the carotid artery was found

July 14 The patient was stuporous and could not be aroused Because of the rales in the lungs, an oxygen tent was advised Death occurred in the afternoon

The *autopsy* revealed the following anatomic diagnoses Bacillus pyocyaneus infection *of the right external auditory* meatus middle ear and temporal bone—the mastoid, petrous and zygomatic elements neuropathy of the right vagus nerve and also of the right glossopharyngeal accessory, and hypoglossal nerves, secondary to infection in the petrous bone, diabetes mellitus, thrombosis of the right internal jugular vein, aneurysm formation and rupture of the right internal carotid artery in the extra cranial portion, extradural hemorrhage, slight over the petrous bone, bronchopneumonia, bilateral, severe, pleuritis fibrous obliterative on the right side, and nephrosclerosis slight

The microscopical findings confirmed the fact that the cause for the multiple cranial nerve palsies was to be found outside the brain stem

PATHOLOGICAL INVESTIGATION OF THE EAR

The entire *right petrous bone* was removed After decalcification it was embedded in celloidin Cutting on a horizontal plane, 750 serial sections were obtained and stained with hematoxylin-eosin and according to Heidenhain-Mallory Unstained sections were mounted for observation under polarized light

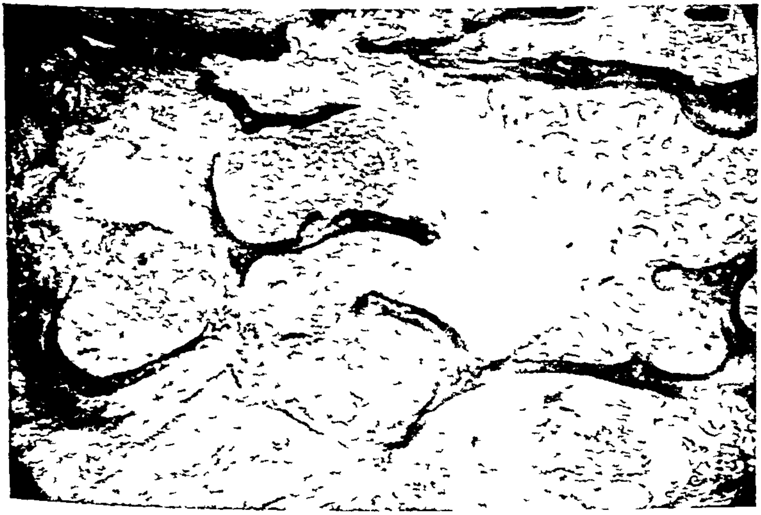


Fig 4 Abscess and new trabecular bone in the petrous apex (Heidenhain-Mallory ×37)

The bone that formed the medial wall of the *operative cavity* was found to be smooth A few *mastoid cells* and a number of *perilabyrinthine cells* were present The walls of the cells were jagged and were in the process of being reabsorbed The mucous-membrane lining of the cell walls had been transformed into high cushions of granulations that almost occluded the lumens of the cells The bases of the cushions of granulations were lined with cysts in typical rosary formation The vessels in the granulating tissue were engorged, but there was no cuffing Wherever a lumen was still preserved it was filled with pus that contained diffuse cellular infiltrations or white blood cells in nests A few cells contained clear transudate

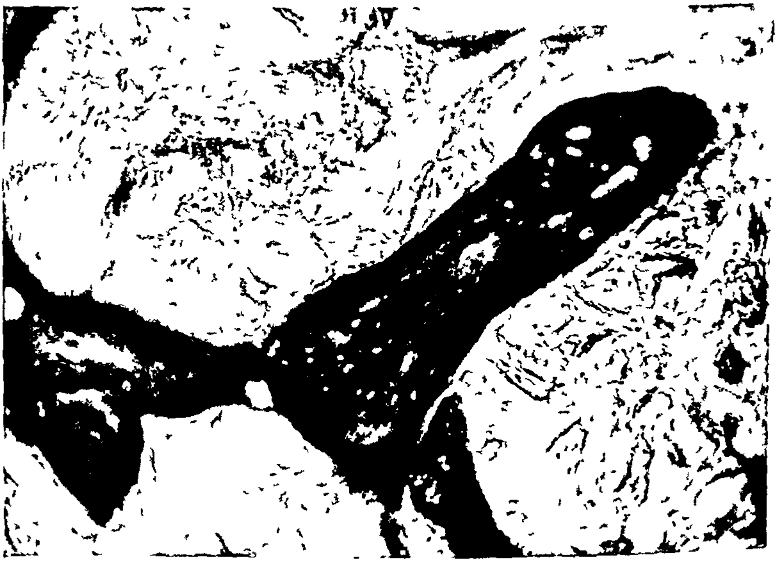


Fig 5 Part of Fig 4 at higher power (Heidenhain-Mallory ×125)

The upper half of the lateral wall of the *facial canal* was missing, and had been replaced by gold foil, which was completely embedded on all sides in granulations and broken into several small particles that were divided into thinner sheets The walls of the lower half of the facial canal were partly splintered, and an attempt to cover the smaller breaks by callus formation had started, the callus contained rare osteoblasts, and had not attained regular lamellar formation

New bone was scattered throughout the remnants of the perilabyrinthine cells and was osteophytic (since there were no osteoblasts) *This* new bone had no relation to the new bone that was formed to repair the destruction around the intercellular septa

Masses of lamellae were embedded in the purulent content of the mastoid cavity, and were thought to be remnants of a *cholesteatoma*

The *ossicles* were missing The *oval window* was wide open, and only the lateral extremity of the annular ligament was preserved The suppurative mass penetrated approximately up to the level of what was originally the stapedial plate High in the stapedial niche there was a break in the bony wall, and for its repair a plug of new bone had been formed The niche of the *round window* contained some clumps of granulation tissue and blood There was a blood clot on the cochlear aspect of the membrane of the round window

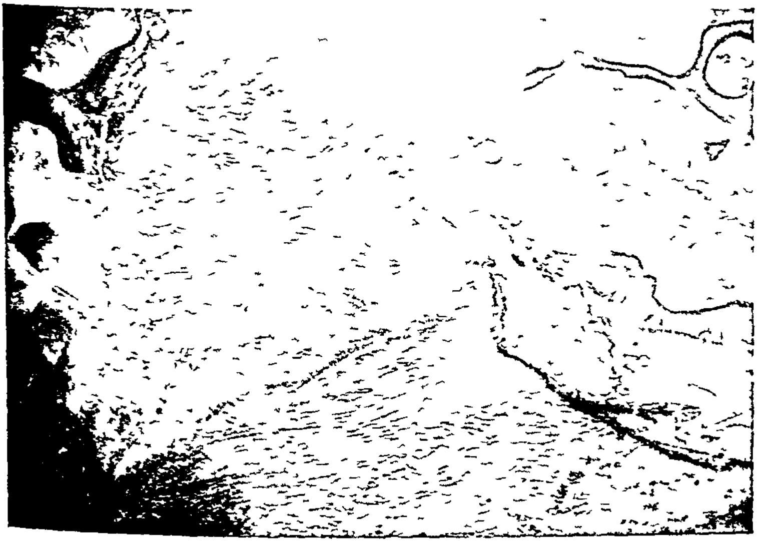
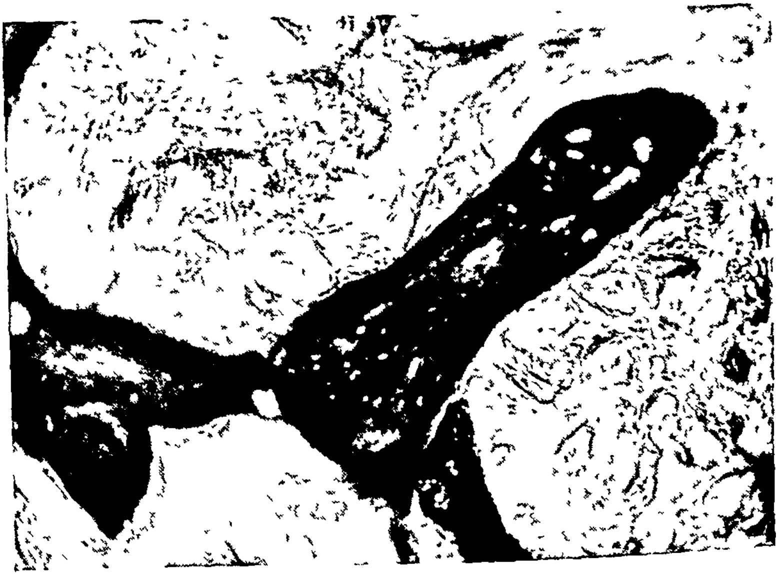


Fig 6 Wide penetration of the apical abscess under the dura through the gap in the tegmen (hematoxylin ×57)

The *vestibulum* was essentially free The endolymphatic space contained only a few clumps of transudate There was extravasation of perilymph in many points There was hemorrhagic infiltration into the basal tissue of the cristae formed into high cushions of granulations that almost occluded the lumens of the cells The bases of the cushions of granulations were lined with cysts in typical rosary formation The vessels in the granulating tissue were engorged, but there was no cuffing Wherever a lumen was still preserved it was filled with pus that contained diffuse cellular infiltrations or white blood cells in nests A few cells contained clear transudate



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The upper half of the lateral wall of the *facial canal* was missing, and had been replaced by gold foil, which was completely embedded on all sides in granulations and broken into several small particles that were divided into thinner sheets The walls of the lower half of the facial canal were partly splintered, and an attempt to cover the smaller breaks by callus formation had started, the callus contained rare osteoblasts, and had not attained regular lamellar formation

New bone was scattered throughout the remnants of the perilabyrinthine cells and was osteophytic (since there were no osteoblasts) *This* new bone had no relation to the new bone showed a most intensive new-bone production The trabeculae of the newly formed bone that originated from the septa showed active osteoblastic seams on many of their surfaces as evidence that further growth could have obliterated many of the cellular spaces of the original structure A regular lamellar structure was not produced, and a lower calcium content was revealed by the conspicuous tinctorial difference More regularity of the lamellar structure, however, was revealed under polarized light

The apical portion of the abscess had a wide opening communicating under the dura, where it formed an *extradural abscess*

The adventitia of the *carotid artery* contained large calcified plaques, and the lumen contained both free and thrombotized blood A wide opening in the bony wall of the carotid canal led into the extradural space, through which its contents protruded under the dura A thrombus covered the opening from the dural side

The *dura* over the tegmen was very thick and cicatrized, and there were some areas of calcification The *ganglion of Gasser* appeared to be intact

Corpora amylacea were found in whole rows in the hiatus of the facial nerve, in the septa of the Gasserian ganglion, high up in the vestibular aqueduct, and were numerous in the internal acoustic meatus where the small vessels showed indications of being eventually transformed into psammomas

DISCUSSION

According to the classification of Brunner (1942, 1946, 1947) this case may be called an acute, protracted, progressive osteomyelitis A detailed discussion of this condition was given lately (Kelemen, 1955 [rev 1957]) so this comment will be limited to the outstanding or unusual findings of this particular case

A characteristic leaping from focus to focus, with intact areas in between, indicating hematogenous spread, was present on both macroscopical and microscopical observation Macro-

The *cochlea* was essentially free Rosenthal's canal was well filled and contained blood in places The spiral ligament contained blood in some spots and calcified vessels Pigment was deposited in the vascular stria The membrane of Reissner was straight in the basal turn and bulged slightly in the middle and apical turns The organ of Corti was flattened, probably artificially The basal turn contained some extravasate The endosteal lining bridged clearly over the orifice of the cochlear aqueduct

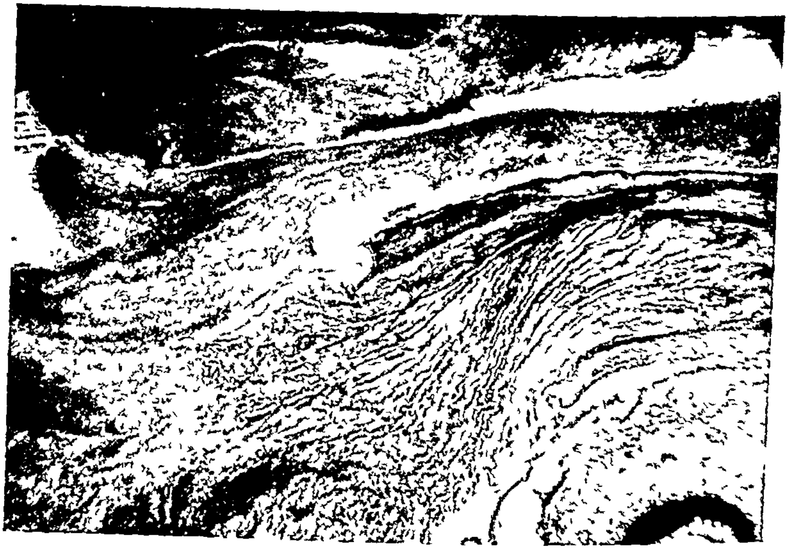

Fig 7 Wide break in the carotid wall thrombus in the arterial lumen and thrombus covering from the intracranial side the break in the canal wall (hematoxylin-eosin ×35)

The *inner acoustic meatus* contained an insignificant amount of blood, which was the only abnormality present within the meatus

The *apex of the petrous bone* was basically diploic in cell structure in its entire extent The septa were essentially intact, but the whole tip was transformed into a large abscess with a center of fibrous organization The periphery of the abscess was a mass of free pus, which was formed among the broken-down trabeculae The fibrous center of the abscess of diabetes and the ear (Kelemen 1955) it was emphasized that hemorrhage has always been a great danger in diabetes and ear disease There can be no doubt that the course of the patient in this case was much influenced by the presence of the diabetes

The problem of pyocyaneous infection in relation to the ear was discussed by Zaufal (1873) In a number of his patients with "blue aural discharge" the "Vibrio cyanagenus,' or the "cylinderbacterium' "Bacterium termo' was isolated Chambers (1900) tabulated 58 cases of otitis media in which the micro-organism was determined, in six of these cases pyocyaneus was found According to his experience if pyocyaneus alone is present, one half of the infections may be cured, with the others proving to be "stubborn Wakefield (1904) obtained pure growth of pyocyaneus, at autopsy from otogenic abscesses of the brain and of the cerebellum as well as from the lungs and the heart

This initial period came to a close with the monograph of Voss (1906) on the role of the pyocyaneus in aural disease He analyzed 37 personal observations and added animal experiments One of his patients (Case No 17) was a man 25 years of age who had had a chronic otitis and intermittent discharge since early childhood The phase of acute exacerbation lasted about six weeks and ended fatally A subperiosteal and a retropharyngeal abscess and an abscess in the temporal lobe developed The mandible was affected as well as the mandibular joint Several operations were necessary Certain aspects of this history show similarity with the presently discussed case, analogies would probably be even more numerous except that roentgenograms were lacking at that period and, consequently, conditions around the pyramid remained unrevealed Even so, the evolution of the retropharyngeal abscess was traced, showing progression from the mandible along the tip of the pyramid

After Voss elucidated the general role of pyocyaneus in otology, Haymann (1914) showed in guinea-pig experiments that artificial infection of the middle ear with pyocyaneus invariably proceeded to a diffuse, suppurative labyrinthitis In a patient with otomastoiditis, Wirth (1926) isolated anscopically, there was manifestation in the external, middle, and internal ear, under the temporal-bone squama, and in the zygoma Invasion of the periosteomyelitic swelling in the region of the zygoma was considered by some authorities as one of the first signs of osteomyelitis The labyrinth was entirely bypassed, the wide penetration through the oval window must have been of recent origin, as it did not reach beyond the level of the stapedial plate Microscopically, between the perilabyrinthine cells with destroyed septa that were replaced by suppurating and granulating masses, other cells were found showing merely collateral, catarrhal signs

The history did not contain anything to suggest a traumatic origin Infection of the venous sinuses must have occurred late in the course of the disease There are conflicting opinions in regard to the role of infection of the dural venous sinuses in osteomyelitis of the temporal bone, some reporters have maintained that sinus infection was the general rule, whereas others have maintained that it was very infrequent

The term osteomyelitis may be applied when the disease of the spongiose substance is manifested both clinically and pathologically Osteitis involves bony plates that do not contain marrow, whereas infection of the marrow is the most important feature in osteomyelitis Osteomyelitis is very rare, notwithstanding the fact that there are temporal bones that never pneumatize and, therefore, remain especially prone to the infection Anatomic conditions fail to explain why an inflammation in the middle ear is followed by a simple otitis in one case and in another by a septic process—an osteomyelitis

In this illness the three outstanding features were the diabetes, the fact that the infecting organism was Bacillus pyocyaneus, and then the resultant pathological bone formation

The *diabetes*, present before the ear infection, was always difficult to control, and in itself probably would have been quite capable of producing an ear complication As insulin was of comparatively little avail, one is reminded of the preinsulin era and its fearful "otite diabétique" In a discussion struction and repair In the middle ear there was a necrosis, which had the characteristics of the comparatively rare otitis media ossificans, with new bone composed partly of osteophytes and partly of the products of osteoblasts In the tip the clear-cut picture of osteomyelitic new-bone formation was encountered No other process is accompanied by any similar intensive attempt at repair to wall off a breach The abscess in the pyramid progressed so that the center was fibrotic Innumerable trabeculae of new bone originated from the old cell partitions, all were formed by osteoblastic carpets No osteoid was present between the old and new bone since time was running short The new bone, as was shown by its tinctorial properties, was low in calcium content, but observation under polarized light revealed its unmistakable lamellar character.

If there had been more time the new trabeculae would have obliterated the formerly diploic cells of the tip completely According to the roentgenographic findings, this condition in the tip could have been about one month old Finally, by condensation of the central portion and isolation among the abscessed parts of the pyramid, the most characteristic product of osteomyelitis—the sequestrum—would have been created

Although surrounded by the severest destruction on all sides, the inner ear still was not dead Some hearing was preserved to the end, and dizziness was the evidence of a damaged but not extinguished vestibular organ, this was borne out by what was seen under the microscope

Destruction of the apical tegmen was followed by the development of an extradural abscess, but the destruction of the bony wall of the carotid canal led to even more serious consequences The contents of the canal, including the artery now protruded through the break in the bony wall, forming an aneurysm The arterial wall was so widely calcified that rupture would have been only a matter of time

The final, dramatic incident was the hemorrhage from rupture of the carotid artery, for which two explanations may be postulated namely, the changes found in the arterial wall hemolytic streptococci that acquired invasive character only after the pyocyaneus appeared, he was able to reproduce this sequence in mouse inoculations Stanley (1947), in discussing pyocyanous infections, stated that pyocaneous bacteremia usually terminates fatally despite any kind of therapy Because he found the organism in the pharynx he concluded that propagation to the ear was logical In Stanley's cases of pyocaneous meningitis, six were preceded by otitis media, and although direct extension could not be demonstrated, there was bacteremia, and, therefore, he concluded that blood-borne metastases were responsible for the meningitis Penicillin therapy inactivates the gram-positive organisms and thus apparently promotes the uninhibited growth of B pyocyaneus and other gram-negative bacilli Recently, the significance of this micro-organism was thoroughly discussed by Senturia (1957)

In the case under discussion, it is difficult to determine whether the strain of pyocyaneus was originally resistant to the numerous antibiotics administered, or if it developed resistance during the long course of the disease

Even without the presence of the diabetes, the pyocyaneous alone would have been able to cause the fatal termination of the osteomyelitis Stanley has described cases in which pyocyaneus sepsis occurred as a terminal complication in patients who were already suffering from other fatal diseases In "Zinsser's Textbook of Bacteriology" (1948) it is stated that middle-ear infections, due to pyocyaneous can be extremely chronic and may persist for as long as five or ten years In this case the rapid progress may be attributed to the presence of diabetes Even with this general disease, diabetes, and the impossibility of any influence on it, the patient fought off for a considerable time the additional but inevitably fatal attack According to the experience of this Department, pyocyaneus, which is so common in external-ear otitis, is frequently the cause of a very protracted middle-ear suppuration on which streptomycin or polymyxin may be of some influence In the present case, however, these two drugs had no effect

The *histological picture* showed a combination of both destruction and repair. In the middle ear there was a necrosis, which had the characteristics of the comparatively rare otitis media ossificans, with new bone composed partly of osteophytes and partly of the products of osteoblasts. In the tip the clear-cut picture of osteomyelitic new-bone formation was encountered. No other process is accompanied by any similar intensive attempt at repair to wall off a breach. The abscess in the pyramid progressed so that the center was fibrotic. Innumerable trabeculae of new bone originated from the old cell partitions; all were formed by osteoblastic carpets. No osteoid was present between the old and new bone since time was running short. The new bone, as was shown by its tinctorial properties, was low in calcium content, but observation under polarized light revealed its unmistakable lamellar character.

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SUMMARY

A fatal case of osteomyelitis of the temporal bone, mandible and zygoma is reported During the eight months of the disease, B pyocyaneus was constantly isolated from the secretions, and a variety of antibiotics were found to be of no help The infection developed against the background of a severe and uncontrollable diabetes

The surgical interventions to check the progress of the disease and the pathological findings in and around the temporal bone are discussed

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itself and the effect of the apical lesion A voluminous body of literature offers ample discussion on both conditions

The calcifications may have been present independently of and long before the final illness In the media very extensive plaques were found that had accumulated most massively in the part of the artery that was nearest the cochlea There was no progression in the plaques to bone formation

According to Kecht (1937) the most frequent and dangerous forms of aneurysm formation in the carotid artery are those produced by erosion In the case under discussion, dehiscences were seen in the bony wall of the carotid canal It is possible that the carotid wall may have been very thin before the last impact and thus would have ruptured easily Guild (1937) emphasized the fact that the carotid wall can be adherent to the wall of the canal, necrosis of the arterial wall can result from the adjacent suppurative process and thus result in hemorrhage Similar topographic conditions induced Guild to advocate caution in the exenteration of the petrous tip if the access was along or through the carotid canal Tato and von Soubirón (1935) and Podestá and Tato (1937) discussed the dangers of carotid hemorrhage in connection with the operation of Ramadier

Mérer (1947) emphasized that although in children the intracanalicular part of the carotid artery contains strong internal and external elastic fibers, in adults the internal elastic lamina is well represented, whereas the external becomes less marked

In the case under discussion, the propagation from the tip of the petrous portion of the temporal bone was spontaneous because exenteration of the apex of the petrous portion was not performed The type of aneurysm encountered must be called "aneurysma spurium" because part of its wall was formed by the abscess in the apex The aneurysm ruptured opposite the portion of the wall that was formed by the apical abscess, close to the most extended calcified plaques

Ballance (1919) made the assertion that "every case of acute otitis which subsequently passes into chronic temporal bone disease has been wrongly treated at first" This statement

A CLINICAL COMPARISON OF MONAURAL AND BINAURAL HEARING AIDS WORN BY PATIENTS WITH CONDUCTIVE OR PERCEPTIVE DEAFNESS*

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New York, N Y

INTRODUCTION

Although there exists an extensive literature dealing with monaural vs binaural hearing, it is only recently that the use of binaural hearing aids have become a practical reality Knudsen,[1] in 1939, Keys,[2] in 1946, Hirsh,[3,4] in 1950, and Broadbent,[5] in 1955, recommended the use of binaural hearing aids by hard-of-hearing individuals Bergman,[6] in 1957, Carhart,[7,8] in 1958, and Markle and Aber,[9] in 1958, reported the successful use of binaural hearing aids by individuals with varying degrees and types of auditory impairment It is the purpose of this report to present "A Clinical Comparison of Monaural and Binaural Hearing Aids Worn by Patients with Conductive or Perceptive Deafness"

SUBJECTS

The subjects included in this study represent two selected groups of patients from the Hearing and Speech Center of New York University-Bellevue Medical Center Fifteen subjects with bilateral conductive deafness and 15 subjects with bilateral perceptive deafness were investigated All subjects had bilateral hearing losses with mid-three frequency (500, 1000, and 2000 cps) averages between 35 and 65 db

In those cases with conductive deafness, the bone conduction

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*Read before the Thirty-Fifth Annual Convention of the American Speech and Hearing Association Nov 17-19 1958 New York N Y

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addition, each subject was tested while wearing two conventional hearing aids—one mounted on each side of the head In each case, the subject was instructed simply to set the volume of the instruments to a comfortable listening level for 50 db of recorded connected discourse (Fulton Lewis, Jr)

The recorded test material consisted of phonetically balanced word lists (Auditory Test W-22) This material is prepared and distributed by Technisonic Studio

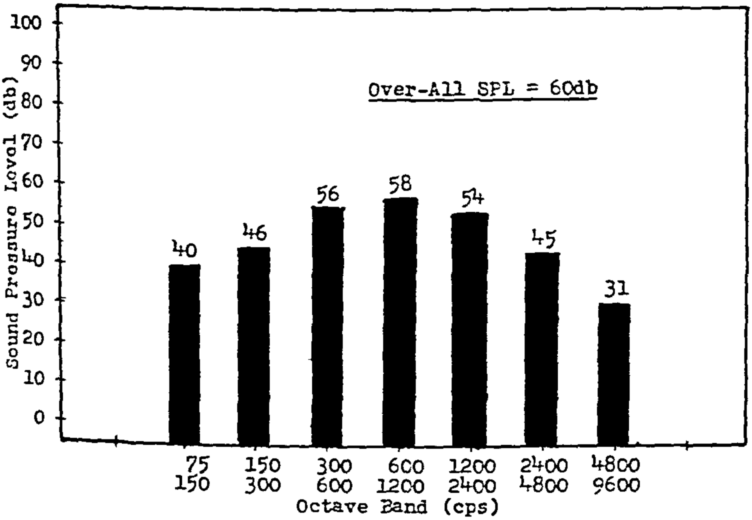

Fig 2 Octave band)analysis of recorded factory background noise (Standard Sound Effect Pecord 300-A) as reproduced through an Ideal T-1 auditory training unit This recording produces a constant acoustic output within ±1 db

The noise used was recorded factory background noise (Standard Sound Effect Record 300-A) which is produced by Standard Radio Transcription Service, Inc , this recording produces a constant acoustic output with ±1 db (see Fig 2)

During the entire testing procedure, the noise was kept at a constant 60 db sound pressure level, this level was determined by measurements made with a General Radio 759-B sound level meter ("C" weighting network) In the presence of this noise, phonetically balanced word lists were presented was not lower than 20 db at any one frequency, and the minimum "air-bone gap" was 25 db In those cases with perceptive deafness, the difference between the air and bone conduction thresholds at any frequency was no more than 10 db

The ages of the subjects varied between 16 and 70 years

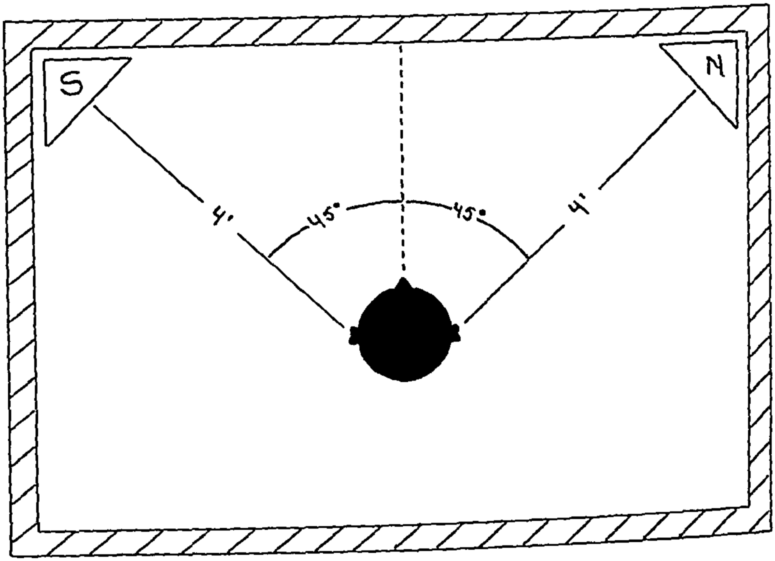

Fig 1 Diagram of test situation illustrating position of subject in relation to signal (S) and noise (N) transducers

PROCEDURE

The subjects were seated in the center of the test room of a conventional two-room suite and, four feet away, and at a 45 degree angle to the left, was placed a loudspeaker (S) which is capable of delivering a signal at calibrated levels Four feet away, and at a 45 degree angle to the right, was placed a second loudspeaker (N) capable of producing recorded noise at calibrated levels (see Fig 1) Loudspeaker S is fed by an Allison 12-B hearing evaluation unit, loudspeaker N is fed by an Ideal T-1 auditory training unit

In order to evaluate the relative values of monaural and binaural hearing aids, each subject was tested while wearing a conventional hearing aid in a conventional manner In provement is 27 4 per cent with a range of 2 to 58, at –10 db, the average improvement is 20 6 per cent with a range of 0 to 46 (see Table I) No patient demonstrated superior performance with the monaural over the binaural hearing aid at any signal/noise ratio

Referring back to Fig 3, and considering the 50 per cent discrimination level, it is noted that the average difference in signal/noise ratios between monaural and binaural listening is approximately 10 db In other words, while keeping the intensity of the signal constant, 50 per cent discrimination can be achieved in the presence of 10 db more noise while wearing a binaural hearing aid than can be achieved while wearing a conventional monaural instrument

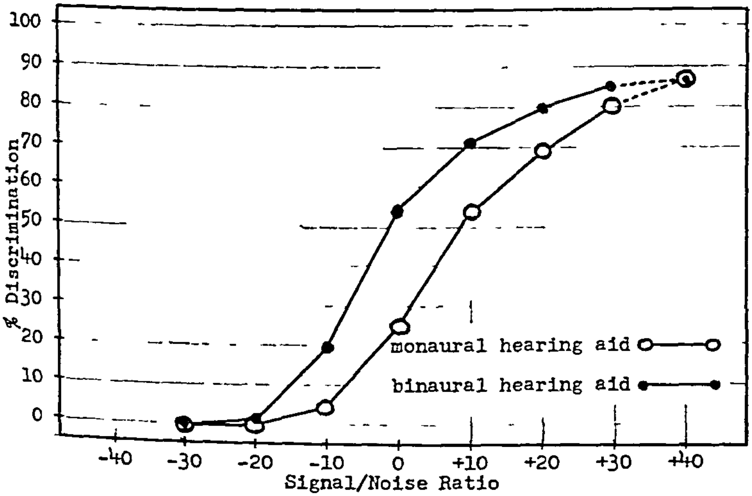

Fig 4 A comparison of monaural and binaural hearing aids worn by 15 subjects with bilateral perceptive deafness when discrimination for speech was determined at various signal/noise ratios (Noise = 60 db SPL)

Perceptive Deafness

As illustrated in Fig 4, binaural hearing aids provide no significant advantage in auditory discrimination over monaural hearing aids when worn in the presence of signal/noise ratios of +30 db or more or –20 db or less, the most significant improvement is demonstrated at signal/noise ratios of at levels of 30, 20, and 10 db above the noise, at the same intensity as the noise, and at 10, 20, and 30 db below the noise, this represents signal/noise ratios of +30, +20, +10, 0, -10, -20, and -30 db. The subjects' discrimination scores were obtained at each of these levels while wearing monaural and binaural hearing aids. The order of presentation was randomized for each subject.

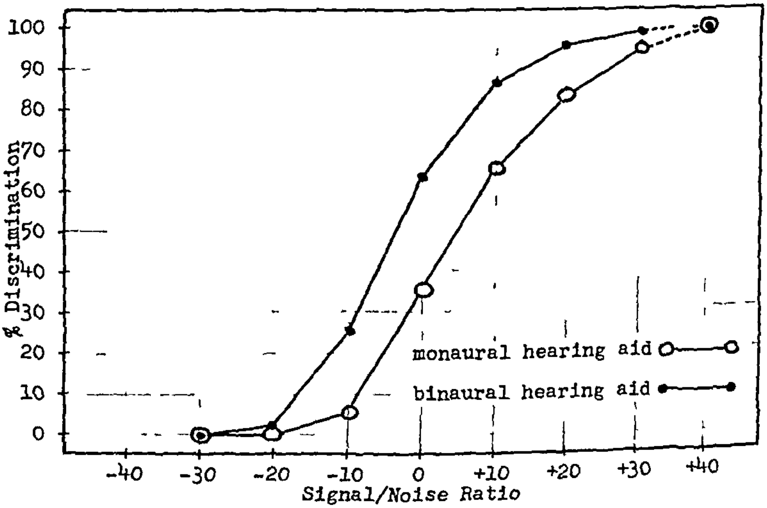

Fig. 3. A comparison of monaural and binaural hearing aids worn by 15 subjects with bilateral conductive deafness when discrimination for speech was determined at various signal/noise ratios. (Noise = 60 db SPL)

RESULTS

Conductive Deafness

As illustrated in Fig. 3, binaural hearing aids provide no significant advantage in auditory discrimination over monaural hearing aids when worn in relatively quiet surroundings (signal/noise ratios of +30 db or more) or in relatively noisy surroundings (signal/noise ratios of -20 db or less), the most significant improvement is demonstrated at signal/noise ratios between +20 and -10 db. At +20 db, the average improvement is 12.4 per cent with a range of 0 to 26, at +10 db, the average improvement is 20.9 per cent with a range of 8 to 52, at 0 signal/noise ratio, the average im-can be achieved in the presence of 10 db more noise while wearing a binaural hearing aid than can be achieved while wearing a conventional monaural instrument

SUMMARY

Within the structure of this clinical experiment, subjects with bilateral conductive deafness provide evidence of the superiority of binaural over monaural hearing aids when worn in listening conditions representing signal/noise ratios between +20 and –10 db Subjects with bilateral perceptive deafness provide evidence of the superiority of binaural hearing aids when worn in listening conditions representing signal/noise ratios between +10 and 0 For both groups, the improvement is most evident at 0 signal–noise ratio

For both the conductive and the perceptive deafness groups, 50 per cent discrimination can be achieved in the presence of 10 db more noise while wearing a binaural hearing aid than can be achieved while wearing a conventional monaural instrument

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+10 and 0. At +10 db, the average improvement is 17.1 per cent with a range of 6 to 42, at 0 signal/noise ratio, the average improvement is 28.6 per cent with a range of 10 to 54 (see Table II).

At +30 db signal/noise ratio, one subject obtained 4 per cent better discrimination and four subjects obtained 2 per cent better discrimination while wearing a monaural hearing aid, at +20 db, one subject obtained 2 per cent improvement in auditory discrimination while wearing a monaural instrument. These differences are not considered to be significant.

TABLE I

Discrimination Scores Obtained While Wearing Monaural and Binaural Hearing Aids in the Presence of 60 db SPL Recorded Factory Background Noise (N = 15 "Conductives")

Discrimination in Noise	Monaural Mean	Monaural Range	Binaural Mean	Binaural Range	Improvement Mean	Improvement Range
S/N +30	95.2%	84-100%	99.7%	94-100%	4.5%	0-14%
S/N +20	84.1%	64-100%	96.5%	80-100%	12.4%	0-26%
S/N +10	66.4%	24-86%	87.3%	76-100%	20.9%	8-52%
S/N 0	35.8%	0-70%	63.2%	10-86%	27.4%	2-58%
S/N -10	6.6%	0-40%	27.2%	0-68%	20.6%	0-46%
S/N -20	0		2.0%	0-34%	2.0%	0-34%
S/N -30	0		0	-	0	-

TABLE II

Discrimination Scores Obtained While Wearing Monaural and Binaural Hearing Aids in the Presence of 60 db SPL Recorded Factory Background Noise (N = 15 "Perceptives")

Discrimination in Noise	Monaural Mean	Monaural Range	Binaural Mean	Binaural Range	Improvement Mean	Improvement Range
S/N +30	81.1%	56-100%	85.1%	58-100%	4.0%	-4-32%
S/N +20	69.4%	50-92%	80.2%	56-96%	10.8%	-4-28%
S/N +10	54.9%	14-72%	72.0%	56-88%	17.1%	6-42%
S/N 0	26.6%	0-52%	55.2%	26-82%	28.6%	10-54%
S/N -10	6.4%	0-22%	19.6%	0-64%	13.2%	0-44%
S/N -20	0		1.3%	0-20%	1.3%	0-20%
S/N -30	0	-	0		0	

Referring back to Fig. 4, and considering the 50 per cent discrimination level, it is noted that the average difference in signal/noise ratios between monaural and binaural listening is approximately 10 db. In other words, while keeping the intensity of the signal constant, 50 per cent discrimination keted as a salicylate under the trade name of Adrenosem® It is reported that the hemostatic activity of epinephrine is also found in adrenochrome Of particular interest is the absence of sympatheticomimetic activity The mode of action is unknown Animal experiments with Adrenosem®[1,2] have shown a decreased extravasation of blood through the capillary walls of the hamster cheek pouch when injured with moccasin snake venom It has been postulated that its mode of action is on the intercellular cement and ground substance about the capillary endothelium There is no direct effect upon the vessel itself Vasoconstrictive activity has not been demonstrated

TABLE I

Survey of the Literature on Adrenosem®

Reference	Incidence of Bleeding Control	Adrenosem	Analysis
Bacala	19 8%	7%	No controls various surgeons with no evaluation of technique time of year
Owings	10%	1%	No controls no criteria for bleeding
Peele	3%	2 2%	No statistical significance
Av Op Time,	19 99 Min	17 39 Min	
Orzac	1 9%	0%	Used penicillin with Adrenosem no evaluation of effect of penicillin on bleeding, no statistical significance What were criteria that permitted no bleeding in 500 cases

There is no effect upon coagulation or bleeding time There is no contraindication of any sort In spite of the fact that its chief activity is upon capillary permeability which is ordinarily not a problem in surgery, there has been considerable literature[3-5] to indicate its effectiveness in a variety of surgical procedures

Table I is a compilation of the recent literature The authors admit to weakness in their statistical data, but all have the impression that adrenochrome helped reduce bleeding The present study developed as a controlled evaluation that would have statistical significance

THE ANTI-HEMORRHAGIC EFFECT OF ADRENOCHROME IN TONSILLECTOMY

A Critical Evaluation[*,†,‡]

ALEX WEISSKOPF, M D ,

San Francisco, Calif

Blood loss with surgery is a continuing spectre Improved surgical technique, management of vascular collapse, blood chemistry and availability of blood for transfusion has markedly diminished surgical risk, nevertheless, excessive bleeding, difficult to control, is still a problem

A wide variety of agents to control bleeding has been offered, ranging through the vitamins K and C, hormones, oxalic acid, calcium and, most recently, the adrenochrome derivative of epinephrine All have been more or less enthusiastically received, however, controlled studies of surgical hemorrhage are noteworthy in their sparsity, for bleeding is most difficult to evaluate How may one tell whether the bleeding stopped due to the use of a particular agent? Most bleeding fortunately stops spontaneously, or the practice of surgery would have "died aborning"

Nose and throat surgery is particularly fraught with the problem of bleeding, since so much of the work involves highly vascular areas which cannot be covered with skin or mucous membrane Because of this, much of the literature and "detailing" of these agents has been directed toward ear, nose and throat and oral surgeons

The literature on adrenochrome is most optimistic Adrenochrome is an oxidation produce of epinephrine which is stabilized for clinical use as a semi-carbazone This has been mar-

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[*] The Adrenosem used in these studies was furnished through the courtesy of the S E Massengill Company Bristol Tenn

[†] Read before the Forty-Third Annual Meeting of the Pacific Coast Oto-Ophthalmological Society Las Vegas Nev May 1959

[‡] From the Division of Otorhinolaryngology University of California School of Medicine San Francisco Calif

Editor s Note This manuscript received in The Laryngoscope Office and accepted for publication June 8 1959

cent Ferric-chloride, Monsel's solution, 1 per cent Neo-synephrine or Epinephrine, postnasal pack or transfusions

c Postoperative oozing during the first 24-hour period requiring examination, even if not treated

These criteria were deliberately made rigid to record the cases of oozing which might otherwise be missed The cases of oozing, if assumed to be due to capillary leakage, would be those most likely to be helped by the Adrenosem®

TABLE II

Average Blood Loss in Each Age Group

Age in Yrs	No of Cases Control	Adrenosem	Vol of cc Blood Loss Control	Adrenosem
1 to 2	5	4	30	38 8
2 to 3	7	13	42 9	41 9
3 to 4	12	15	41 3	64
4 to 5	19	19	89 5	56 3
5 to 6	15	15	93 0	75 7
6 to 7	15	15	77 7	99 2
7 to 8	5	7	87	103 6
8 to 10	9	6	111	95
10 to 12	4	6	93 8	130
Total Cases	91	98		

RESULTS

Tables II and III graphically represent the results of the study

1 There were insufficient cases within each age group for significant statistical evaluation The lack of consistent difference within the various age groups between the control and treated cases indicates no correlation between age and response to Adrenosem®

2 In the 98 control cases there were seven with excessive bleeding, making a total of 7 7 per cent as compared to 8 1 per cent in the 98 medicated ones This likewise is of no significance, and agrees with the clinical impression gained at surgery It was impossible to differentiate control and Adrenosem® cases by the ease of the operation

3 Statistical interpretation is shown in Table IV There

METHODS

The following conditions were carefully observed to limit the variables which could control blood loss

1 Two-hundred consecutive cases limited to children up to age 12 were used Eleven were discarded from the data due to errors in measurement at time of surgery

2 Standard premedication, consisting of codeine and atropine, according to age and weight

3 Ether anesthesia by insufflation

4 Random selection of patient without the knowledge of the surgeon This was done by the ward nurse who was instructed to give the Adrenosem® with the premedication to alternate cases

5 Elimination of cases with factors which may influence bleeding These included recent infection requiring antibiotics, rheumatic fever and kidney disease

6 Consistent surgical technique, using the Crowe-Davis position and McIvor gag The adenoids were removed with curette and punch forceps One sponge saturated with 10 per cent tannic acid jelly was used to pack the nasopharynx in all cases Tonsillectomy was done by dissection and snare Upper pole bleeders were routinely clamped and tied before dissecting Those remaining were clamped when necessary An average of four to six ties were routinely used No record of the number of ties was kept Adrenosem® has no reported effect on vessels larger than capillaries

7 Careful measurement of blood loss This was done by using only a measured amount of citrated water for irrigation of the tubing during and upon completion of surgery

8 Definition of bleeding There is no consistency in the literature regarding the criteria of "unusual bleeding" The following were used

a Persistent puddling of blood at completion of surgery

b Need for agents other than the ties and one Amertan sponge to control bleeding These agents included 1 per cent Ferric-chloride, Monsel's solution, 1 per cent Neo-synephrine or Epinephrine, postnasal pack or transfusions.

c Postoperative oozing during the first 24-hour period requiring examination, even if not treated.

These criteria were deliberately made rigid to record the cases of oozing which might otherwise be missed. The cases of oozing, if assumed to be due to capillary leakage, would be those most likely to be helped by the Adrenosem®.

TABLE II

Average Blood Loss in Each Age Group

Age in Yrs	No. of Cases Control	No. of Cases Adrenosem	Vol. of cc Blood Loss Control	Vol. of cc Blood Loss Adrenosem
1 to 2	5	4	30	38.8
2 to 3	7	13	42.9	41.9
3 to 4	12	15	41.3	64
4 to 5	19	19	89.5	56.3
5 to 6	15	15	93.0	75.7
6 to 7	15	15	77.7	99.2
7 to 8	5	7	87	103.6
8 to 10	9	6	111	95
10 to 12	4	6	93.8	130
Total Cases	91	98		

RESULTS

Tables II and III graphically represent the results of the study.

1 There were insufficient cases within each age group for significant statistical evaluation. The lack of consistent difference within the various age groups between the control and treated cases indicates no correlation between age and response to Adrenosem®.

2 In the 98 control cases there were seven with excessive bleeding, making a total of 7.7 per cent as compared to 8.1 per cent in the 98 medicated ones. This likewise is of no significance, and agrees with the clinical impression gained at surgery. It was impossible to differentiate control and Adrenosem® cases by the ease of the operation.

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METHODS

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a Persistent puddling of blood at completion of surgery

b Need for agents other than the ties and one Amertan sponge to control bleeding These agents included 1 per was a difference of 2.1 cc. in blood loss between the two groups. This is well within the limits anticipated by pure chance (i.e., standard error of the difference of the means= 6.5 cc.) and is, therefore, not significant. There was likewise no correlation between sex and bleeding; however, when the bleeding of all cases is compared to age (see Fig. 1), a

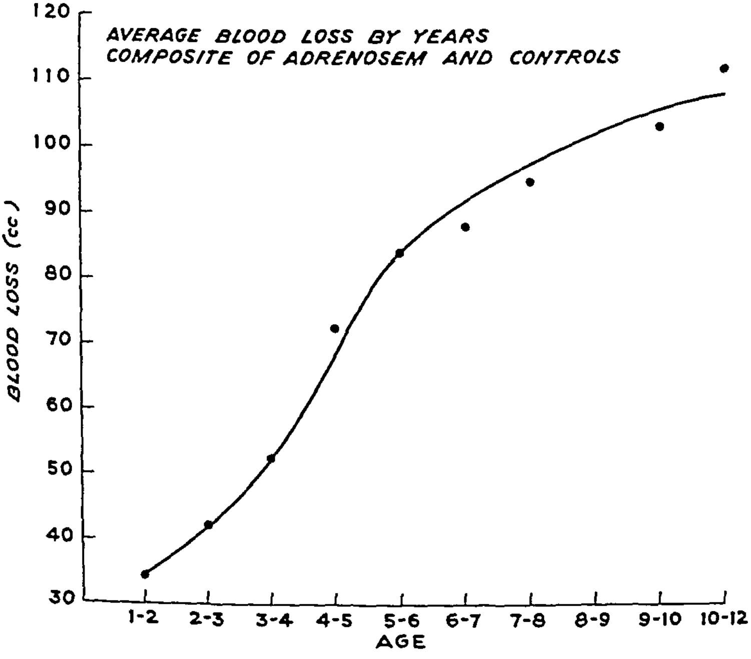

Fig. 1

sigmoid curve is derived. This is graphic evidence of the common observation that bleeding increases with age until a plateau is reached.

4. As a matter of interest, the bleeding and coagulation times were compared to the blood loss by the X^2 method. This showed no correlation between the tests and the amount of blood loss.

DISCUSSION

It is apparent that there is no discernible difference, clini-

TABLE III

Complications and the Means of Their Control in Each Age Group

Age in Yrs	Complications Control	 Adrenosem
1 to 2	0	0
2 to 3	0	0
3 to 4	0	1 Post nasal pack 2 Ooze (1% Neosyn)
4 to 5	Aden ooze	0
5 to 6	1 Aden ooze (FeCl$_3$) 2 General ooze	0
6 to 7	Post op bleeding	1 Aden ooze during surgery and post op 2 Aden ooze 3 Many ties, aden ooze
7 to 8	Aden ooze	General ooze
8 to 10	1 Post nasal pack and transfusion 2 Ooze	
10 to 12		1 Gen'l ooze (Adrenoline, Monsels) 2 Prof bleeding (Neosyn , FeCl$_3$)
Complications Total Cases	7	8
Per Cent	7 7%	8 1%

TABLE IV

Statistical Evaluation of Experimental Results
Adenosem Study of T & A
189 Children, Ages 11 mos to 12 yrs —May, 1956 to Aug 1957

	Total	Sex	Mean Volume	S D *	Sn†	Sn of Diff of Means‡
Control	91	M 54 F 40	78 2 cc	45 3 cc	4 8 cc	6 5 cc
Adrenosem	98	M 55 F 43	76 1 cc	42 9 cc	4 4 cc	

Conclusion—No Statistical Significance

*S D —Standard deviation of mean expected variability (±) of individual samples

†Sn—*Standard error of the mean expected variability* (±) of the means

‡Sn Standard Error of Difference of Means—The difference to be expected by chance

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cal or statistical, between the control and treated cases of this series In all fairness it must be emphasized that this study evaluates the Adrenosem® action in a series of cases where bleeding was kept to a minimum The bleeding was adequately controlled by careful surgical technique, including unimpaired visualization, clear airway, minimal trauma, avoidance of extra-capsular dissection, immediate tying of blood vessels and meticulous removal of lymphoid tissue from the nasopharynx

Proctor and Douglass[10] have shown a 1 per cent incidence of bleeding in over 1600 cases without special medication This minimal figure as compared to the present study is probably attributable to a difference in criteria of bleeding In any case, the significance is not in the figure itself but in the fact that highly creditable results were obtained by surgical management alone They concluded that "as yet there is no adequate justification for the widely accepted belief that the so-called hemostatic drugs will reduce the incidence of postoperative bleeding below that figure to be expected with careful surgical technique alone" This study corroborates this opinion and emphasizes again the need for critical evaluation of therapeutic agents The value of the hemostatic drugs is so difficult to assess that only the most careful analytical studies should be considered adequate

SUMMARY

1 The anti-hemorrhagic effect of adrenochrome semi-carbazone (Adrenosem®) was studied on a series of 189 adenotonsillectomies of which 91 were unmedicated controls

2 No clinical or statistical difference could be discerned between the treated and control cases

3 Evidence was presented that surgical technique is statistically of greater importance in decreasing blood loss than any known medication

4 An incidental finding was the lack of correlation between the amount of blood loss and the bleeding and coagulation time pharynx can be inspected serially and systematically with full illumination reflected from the mirror Even with the soft palate retracted it is impossible to examine the choanae adequately without use of the mirror The author routinely uses the one-inch wide Penrose tubing which has been secured through the nose by a previously introduced 14 Fr soft rubber catheter Light tension is then placed both on the remaining portion of the Penrose through the mouth and the end coming through the nose, and both ends are secured with a short Halstead forceps to prevent slippage The one-inch width allows a more even pressure application to the soft palate and effectively elevates it without tearing, which often happens when the catheter alone is used The device frees both hands for use of the warmed mirror and the punch forceps

The surgeon is seated at the head of the patient who is in the supine Rose position with the head low and practically in the lap of the operator The Davis or McIvor mouth gag is used during the tonsillectomy and remains in place during the adenoidectomy The opposite end of the tongue blade is suspended from the edge of the Mayo tray which is over the chest of the patient This frees the assistant's or anesthetist's hand for more pressing duties Since the usual tongue blade used frequently obscures the lingual tonsil and the base of the tonsil fossa itself, the operation is finished with the Jenning's gag and separate tongue depressor (thin) so that these areas may be inspected more thoroughly, and the surgeon can thus rest assured that the tonsillectomy and adenoidectomy is complete With complete removal of the adenoids there is less chance of postoperative hemorrhage If this eventuality is anticipated, the author used either the Fox nasal balloon or the 30 cc Bardek bag into which 10 to 15 cc of air has been put via syringe and No 26 needle Removal of the system is simply by letting the air out with a No 20 needle and pulling the catheter and collapsed bag out through the nose

The patient, of whatever age, will tolerate the air balloon much better than the usual gauze adenoid packing which soon becomes very odoriferous and most difficult to remove through the mouth

THREE NEW ADENOID PUNCH FORCEPS FOR ADENOIDECTOMY

MERRILL LINEBACK, M.D.,
College Park, Ga.

Adenoidectomy with or without tonsillectomy is the most frequently performed surgical operation, being largely a hit and mostly a miss affair. In no other field of surgery, obstetrics excepted, is the field of vision so limited and, with respect to the adenoids, are the results as poor. Not a few surgeons pride themselves on the rapidity of technique and the number of extirpations per hour, seldom do they concern themselves with the long term effects of a poorly performed adenoidectomy. These are "regrowth" and continued Eustachian tube blockage maintaining deafness in a child, either as a result of a "collapsed" ear drum or fluid in the middle ear, or both.

The adenoids and tonsils do not "regrow" if they are completely removed the first time. It is the tags that remain which hypertrophy after repeated reinfections and present later as "regrowths." Cysts in the adenoid region of the adult are often unsuspected until the adenotome is used over a smooth appearing and "flat" nasopharynx. The author has had two cases of adult cysts which had inspissated putty-like material in the uncovered adenoid, one was a patient 22 years old, and the other was 24 years, both females.

Surgeons who work with congenital deformities of the heart have found that a dry field and direct vision are much to be preferred over the blind techniques.

Direct vision during adenoidectomy is never precise. It is impossible to throw light into all reaches of the crypts and fossae of the nasopharynx, particularly in the region of the choanae, but with the large No. 6 laryngeal mirror, which has been previously warmed, the entire region of the naso-

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SUMMARY

Three new modifications of adenoid punch forceps are presented with indications for their use The author's routine for complete tonsillectomy and adenoidectomy is briefly described With complete removal of tissue there is less possibility for postoperative hemorrhage, and "regrowth" chances are thus eradicated These forceps may also be used as biopsy forceps when a tumor of the fossae or choanae is suspected They are manufactured by the Storz Instrument Co, 4570 Audubon Ave, St Louis 10, Mo

124 West Princeton Ave

DESCRIPTION OF FORCEPS

The forceps labeled 1 in Fig 1 is a reverse curve, and has a reverse bite for use in the choanae The punch itself is triangular in shape, and the three sides are sharp, each basket of the punch has two parallel wires as a catch for the bits of tissue as they are punched out

No 2 forceps is curved toward the operator when held in the right hand The punch head is so opened that it bites to the left when placed in the nasopharynx and is used chiefly in the left Rosenmueller fossa The same instrument can be made for a left handed operator by curving the head in the opposite or mirror image direction In that case the instrument would be used in the right fossa

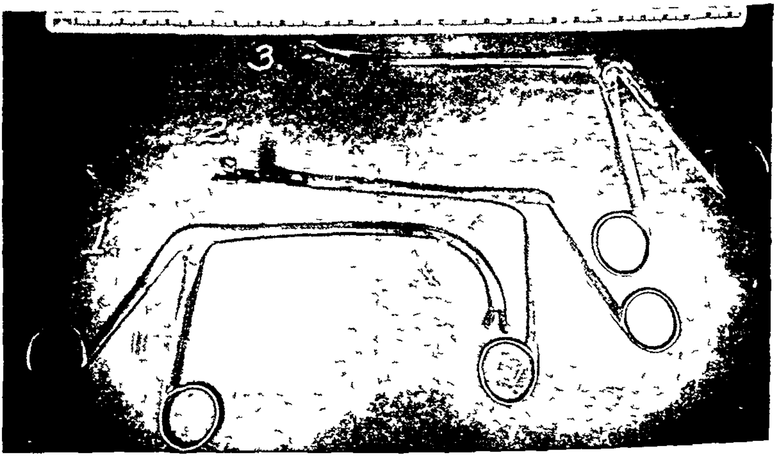

Fig 1 Adenoid punch forceps 1 is reverse curve-reverse biting 2 is full 90 degree curved toward the right-handed operator biting downwards for the left Rosenmueller fossa 3 is full 90 degree curved toward the operator biting upward for the right fossa All three are 15 cms in length from the fulcrum to the head

No 3 forceps is again curved toward a right handed operator but with the head biting upwards, and is thus chiefly used in the right Rosenmuelled fossa If the instrument is designed for a left handed operator, it would be used in the left fossa All three forceps are 15 cms long from the fulcrum to the head itself

SUMMARY

Three new modifications of adenoid punch forceps are presented with indications for their use The author's routine for complete tonsillectomy and adenoidectomy is briefly described With complete removal of tissue there is less possibility for postoperative hemorrhage, and "regrowth" chances are thus eradicated These forceps may also be used as biopsy forceps when a tumor of the fossae or choanae is suspected They are manufactured by the Storz Instrument Co, 4570 Audubon Ave, St Louis 10, Mo

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REVIEW OF THE AVAILABLE LITERATURE OF THE LARYNX FOR 1958[*]

FRANCIS E LEJEUNE, M D
and
MERCER LYNCH, M D ,
New Orleans, La

PHYSIOLOGY

The student of laryngeal physiology encounters a wealth of diverse information on the subject of voice formation Because of lack of adequate equipment, few investigators have made any attempt to discover the secrets of the vibratory pattern The scientific advances of ultra high speed photography and the electronic synchronstroboscopy have made this possible Using the ultra high speed motion picture, Timcke and associates[1] explored the details of laryngeal vibration during the opening and closing phases of the vibratory cycle Their technique is given in detail Their findings are given regarding (A) chest voice at weak to medium intensity, (B) chest voice at extremely weak intensity, (C) intensity changes in chest voice, and (D) pressure changes in chest voice

In an exhaustive investigation Moore and von Leden[2] conclude that voice production is a dynamic process constantly changing in behavior rather than a repetition of the same vibratory movement These investigations carried through laughter, abduction, adduction, vibration and numerous other phases are well depicted graphically The fundamental pur-

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[*] From the Department of Otolaryngology Ochsner Clinic New Orleans La

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pose of this investigation was to discover new information about the physiology of the normal larynx during voice production Moore and von Leden[2] propose a new term, "dyscrotic dysphonia," to express the physiologic vibratory pattern in the voice quality presently called "glottal fry"

Nakamura and associates[3] made a study of the electrical activity of five intrinsic laryngeal muscles of the dog during respiration by means of electromyographic recordings They noted that the abductor was active during inspiration, and the adductors showed activity during expiration except the thyroarytenoideus, which remained quiet throughout the respiratory cycle No change in activity after detachment of the trachea indicates that respiratory movements of the glottis may be controlled centrally without reference to a local sensory information The pattern of activity of the laryngeal muscles was extremely similar to that of intrinsic respiratory muscles

Furstenberg[4] reviews the pathway of motor nerve control of the larynx and upper extremities In experimental study on monkeys the primary motor area for the larynx was located, also, additional motor areas to the larynx were definitely demonstrated These motor areas may be spared when the primary motor field or the pyramidal systems are destroyed Obviously, these reserve motor areas would help in laryngeal function Some of these additional motor areas are in fields where the connections suggest they have to do with emotional responses.

In patients with hysterical aphonia there is obviously a central inhibitory effect upon the corticobulbar fibers carrying motor impulses to the nucleus ambiguous When emotionally aroused, these patients may scream loudly or speak audibly and distinctly Furstenberg states that secondary motor areas are definitely demonstrated in the cortex of monkeys, it is logically assumed phylogenetically that a similar pattern of motor innervation for the larynx is present and more highly developed in man

During "silent speech" Faaborg-Andersen and Edfeldt[5] noted an increase in electrical activity in the vocal and mylohyoid muscles and a reduction in the posterior crico-arytenoid muscle The change in electrical activity was considerable in subjects with low reading ability This work was performed on ten volunteers, all free of disease, electrodes being inserted into the vocal and post-crico-arytenoid muscles and into the mylohyoid muscle

Tschiassny[6] coined the word necrophonia to designate the laryngeal sounds that may appear under certain conditions as a spontaneous postmortem phenomenon He shows this phenomenon by use of models and then by use of larynges and air under pressure It is explained by rigor mortis and gas forming bacilli in the lungs and air passages

PATHOLOGY

Epstein[7] presents a simple, practical technique for systematic histologic examination of the total epithelial field of the larynx At operation or necropsy the larynx is opened posteriorly by longitudinal splitting, and it is forcibly kept open Longitudinal strips from the epiglottis to the lower border of the cricoid are obtained in a regular pattern well described by the author This stripping technique is considered far superior to other methods in vogue for histologic examination of the larynx

Keen and Wainwright[8] collected, dissected and studied 133 larynges from adult subjects for evidence of bony changes, the methods of study included radiography and histology A definite pattern of progressive ossification for the thyroid, cricoid and arytenoid cartilages was noted There were considerable sexual differences in the manner in which the ossification process affected the thyroid cartilages The radiologic observations were confirmed by histologic sections In addition, as a precursor to ossification, vascular changes and fibrillary degeneration were noted in the laryngeal cartilages It was noted that bony changes in the thyroid and cricoid cartilages usually begin during the third decade but, in general, correlation between advancing age and progressive ossification was poor The conclusion is drawn that "ossification in the laryngeal cartilages is a genetically controlled pose of this investigation was to discover new information about the physiology of the normal larynx during voice production. Moore and von Leden[2] propose a new term, "discrotic dysphonia," to express the physiologic vibratory pattern in the voice quality presently called "glottal fry."

Nakamura and associates[3] made a study of the electrical activity of five intrinsic laryngeal muscles of the dog during respiration by means of electromyographic recordings. They noted that the abductor was active during inspiration, and the adductors showed activity during expiration except the thyroarytenoideus, which remained quiet throughout the respiratory cycle. No change in activity after detachment of the trachea indicates that respiratory movements of the glottis may be controlled centrally without reference to a local sensory information. The pattern of activity of the laryngeal muscles was extremely similar to that of intrinsic respiratory muscles.

Furstenberg[4] reviews the pathway of motor nerve control of the larynx and upper extremities. In experimental study on monkeys the primary motor area for the larynx was located; also, additional motor areas to the larynx were definitely demonstrated. These motor areas may be spared when the primary motor field or the pyramidal systems are destroyed. Obviously, these reserve motor areas would help in laryngeal function. Some of these additional motor areas are in fields where the connections suggest they have to do with emotional responses.

In patients with hysterical aphonia there is obviously a central inhibitory effect upon the corticobulbar fibers carrying motor impulses to the nucleus ambiguous. When emotionally aroused, these patients may scream loudly or speak audibly and distinctly. Furstenberg states that secondary motor areas are definitely demonstrated in the cortex of monkeys; it is logically assumed phylogenetically that a similar pattern of motor innervation for the larynx is present and more highly developed in man.

During "silent speech" Faaborg-Andersen and Edfeldt[5] noted an increase in electrical activity in the vocal and mylohyoid muscles and a reduction in the posterior crico-arytenoid muscle The change in electrical activity was considerable in subjects with low reading ability This work was performed on ten volunteers, all free of disease, electrodes being inserted into the vocal and post-crico-arytenoid muscles and into the mylohyoid muscle

Tschiassny[6] coined the word necrophonia to designate the laryngeal sounds that may appear under certain conditions as a spontaneous postmortem phenomenon He shows this phenomenon by use of models and then by use of larynges and air under pressure It is explained by rigor mortis and gas forming bacilli in the lungs and air passages

PATHOLOGY

Epstein[7] presents a simple, practical technique for systematic histologic examination of the total epithelial field of the larynx At operation or necropsy the larynx is opened posteriorly by longitudinal splitting, and it is forcibly kept open Longitudinal strips from the epiglottis to the lower border of the cricoid are obtained in a regular pattern well described by the author This stripping technique is considered far superior to other methods in vogue for histologic examination of the larynx

Keen and Wainwright[8] collected, dissected and studied 133 larynges from adult subjects for evidence of bony changes, the methods of study included radiography and histology A definite pattern of progressive ossification for the thyroid, cricoid and arytenoid cartilages was noted There were considerable sexual differences in the manner in which the ossification process affected the thyroid cartilages The radiologic observations were confirmed by histologic sections In addition, as a precursor to ossification, vascular changes and fibrillary degeneration were noted in the laryngeal cartilages It was noted that bony changes in the thyroid and cricoid cartilages usually begin during the third decade but, in general, correlation between advancing age and progressive ossification was poor The conclusion is drawn that "ossification in the laryngeal cartilages is a genetically controlled normal occurrence, and is not a simple degenerative process associated with advancing age."

ANOMALIES

Triboletti[9] reports a case of a rare congenital anomaly, a common laryngotracheo-esophageal tract extending from below the bifurcation of the trachea up to and involving the posterior surface of the larynx in a newborn infant. The esophagus was patent throughout and communicated with the stomach. The baby died on the fourth day of life.

Sonninen and Vaheri[10] report a case of laryngeal asymmetry, a frequent cause of voice disorder. The asymmetry produced considerable vocal difficulty consisting of the left cord's being shorter and on a higher level than the right cord, giving the glottic chink an oblique appearance. Surgical correction by splitting the thyroid cartilage in the median line and inserting a piece of rib cartilage between the thyroid alae and the perichondrium resulted in fixation of the cord in medioposition. Rehabilitation of the voice was good, and the patient was able to resume his occupation as a lawyer.

DISEASES

According to Silverblatt,[11] diseases of the larynx are treated predominantly by surgical procedures except for antibiotics in the acute infectious reactions and streptomycin in tuberculous laryngitis. He has used antibiotic steroid combinations in many laryngeal problems, including acute laryngitis, contact ulcers, laryngeal polyps before and after operation, papillomas and postoperatively in cases of hyperkeratosis and leukoplakia, for the past two years with notable benefit.

Myerson[12] urges vocal rest in certain laryngeal conditions characterized by edema or inflammatory reactions on the vocal cords. He rightly advocates vocal rest in the early stages of vocal nodules and the edematous manifestations after excessive smoking. Vocal rest is as important preoperatively as postoperatively. The cords should not be used until the operated area on the cord has had a chance to heal. In cases in which fibroblasts develop there is little reason to consider vocal rest, as fibrous tissue is irreversible, and no amount of silence will make it disappear

Laskiewicz[13] presents an interesting article on pharyngolaryngeal disturbances due to cervical spondylosis He attributes cervical spondylosis to the degenerative changes within the small articulations of the cervical spine as a consequence of over-strain or prolonged traumatic action on the surfaces of the spinal articulations, their articular bands and ligaments, which become relaxed This produces pressure upon the spinal roots of different cervical sectors, and with time, deposition of calcium within the spinal articulations This new bone formation is significant, and frequently the patient complains of a burning sensation of the posterior part of the tongue, soreness and a lump in the throat, and difficulty in swallowing solid foods associated with prickly pain extending to the lower border of the cricoid cartilage The laryngeal mucosa is pale, the vocalis muscle is weak, and there are phonatory disturbances, such as vocal weakness and hoarseness defined as "syndrome sympatico-vocal " The therapy of this condition is briefly discussed

Trible[14] reports a case of sarcoidosis of the larynx in a Negro woman Several granulomatous growths removed from the vocal cords established the diagnosis Sarcoidosis is a protean disease which must be distinguished from histoplasmosis and tuberculosis The condition was treated with prednisone, the patient receiving from 20 to 30 mg in divided doses daily for three months This resulted in disappearance of the laryngeal lesions, but they later recurred in spite of therapy

Ciacovaner[15] points out that management of hyperkeratosis of the larynx is extremely difficult because some of these lesions are considered precancerous The changes taking place are unrecognizable by visual examination The definite diagnosis depends upon the microscopic findings, and this metamorphosis may take place at any time

Hyperkeratosis may be localized or diffuse in the larynx also termed keratosis, leukoplakia or pachydermia, it is a thickening of the layers of the epithelium, especially the corninormal occurrence, and is not a simple degenerative process associated with advancing age"

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Lester and associates[18] are convinced that the diagnosis of primary laryngeal blastomycosis is extremely difficult to make, and the condition is frequently confused with tuberculosis and carcinoma of the larynx This is exemplified by a case which they report in detail From a thorough review of the literature they believe it represents the thirteenth case of blastomycosis of the larynx to be reported The diagnosis was difficult to establish because the laryngeal lesion resembled tuberculosis, but the patient failed to respond favorably to tuberculous therapy, however, once the diagnosis was established, the patient was given 225 mg of 2-hydroxystilbamidine daily, administered intravenously, for 30 days Thereafter, improvement was rapid, and lost weight was regained The appearance of the laryngeal lesion is fully described

King and Cline[19] report a typical case of disseminated histoplasmosis with laryngeal lesions They believe that the larynx is involved with this disease much oftener than current reports would indicate Granulomatous lesions of the larynx should be suspected to be histoplasmosis even if the reaction to the histoplasmin skin test is negative A definite diagnosis should be established by biopsy and culture No drug has yet proved effective in the treatment of this disease, although ethyl vanillate has shown some promise Laboratory results from use of amphatericin B have been encouraging, but use of this drug was unsuccessful in the case reported by King and Cline

In a study of executive's dysphonia Gardner[20] reminds us that strain and tension are widely recognized as affecting functions of the human nervous system He continues "Comfied portion, and may be slightly raised, rather dense and thickened, or it may be a greyish white sessile growth or a red thickening of the cord. It may also appear as a white, warty growth with sharp, spiny protuberances.

The condition in general is due to chronic irritation, such as from excessive smoking, overindulgence in alcohol, abuse of the voice, inhalation of fumes and dust or chronic infection of the upper respiratory tract. If the lesion is small and not too thick, the condition may subside simply by elimination of all causes of irritation; however, more frequently these areas have to be removed surgically by direct laryngoscopy, suspension laryngoscopy and stripping, or laryngofissure. One should be reluctant to perform laryngectomy even if the lesions are extensive unless proved malignant, because they are usually superficial and non-infiltrating. In such cases radiation therapy is the first choice. If the disease involves both cords and crosses the anterior commissure, stripping the involved areas, eliminating irritating causes and close observation are indicated. If malignant changes occur, laryngectomy becomes necessary.

Siegler[16] reports a case of leukoplakia of the larynx complicated by carcinoma. It is generally agreed by laryngologists that persistent leukoplakia on a vocal cord will eventually become malignant unless removed before the degeneration occurs. From 1954 to 1957 Siegler observed a patient with leukoplakia of one vocal cord which had a clinical appearance of carcinoma. Repeated biopsies from a bulky mass of hyperkeratosis were reported to yield negative results. The clinical appearance so simulated a malignant tumor that extensive radiation was administered with complete disappearance of the keratotic mass in 1955. As usual after irradiation, there was considerable edema of the laryngeal structures until October, 1956, when the edema disappeared and the cords appeared normal. In April, 1957, hoarseness and leukoplakia recurred with extensive involvement, and biopsy showed squamous cell carcinoma. One wonders whether early surgical removal would have prevented laryngectomy.

Priest[17] presents an excellent open-minded discussion of the tion with the statement that it was "negative" They fail to mention the status of the epiglottis, the corniculate and cuneiform cartilages or the appearance of the mucosa covering the arytenoid area, all of which are vitally important in the evaluation of laryngeal stridor Little information on the results of examination seven years later is given to compare with the condition found in the first year The diagnosis was chondrodystrophy calcificans congenita, a condition which rarely occurs in the larynx

STENOSIS

In an excellent and lengthy article Holinger and Johnston[23] discuss their methods of management of chronic laryngeal stenosis This condition is usually associated with a distressing degree of disability Physical impairment ranges from respiratory effort, stridor, and even chronic anoxemia, to actual acute obstruction necessitating tracheotomy Holinger and Johnston state that formerly diphtheria was the greatest causative factor in producing laryngeal stenosis, but trauma is rapidly replacing acute laryngeal diseases as the commonest cause of chronic laryngeal stenosis Treatment is well described and illustrated by numerous photographs The importance of maintaining a low tracheotomy is stressed, and in traumatic cases it is essential that reparative procedures be instituted within the first few days after the accident, before the cartilages have become fixed in their compressed or obstructing position and before scar tissue forms This article is based on experience gained in a series of 163 cases of chronic laryngeal stenosis treated during the past ten years This is good reading for all who are interested in this phase of laryngology

SPASM

Fogel and Hinderer[24] state that laryngospasm has been recognized as a possible but rare complication of electroconvulsive therapy It was concluded after extensive studies that laryngospasm of varying intensity and duration occurs during the apneic phase of every electroconvulsive treatment in the unpremedicated patient Succinylcholine chloride efmunication by speech is a synthesis of functions whose finely balanced co-ordinations are easily disturbed by stimuli from the *autonomic and sympathetic nervous systems*. The business executive is exceptionally vulnerable to the development of functional vocal disorders. His work is accomplished by dictation, conferences, conversations by telephone—and the strain and tension are inherent threats to his position of commanding or supervising other personnel, and even to his survival in today's highly competitive commercial enterprises." Gardner reports the results of a study of 49 executives having functional vocal disorders, most of whom suffered from functional dysphonia. Those treated by proper voice therapy responded in excellent fashion, whereas those who did not accept voice therapy remained unimproved. In addition, other forms of treatment advised included antihistaminics, hypoallergenics, diet, vitamins, tranquilizers or sedatives, heat, massage, and general relaxation.

Considerable attention has recently been focused on visceral manifestations of rheumatoid disease. Gresham and Kellaway[21] report a case of a woman with severe rheumatoid disease admitted to the hospital because of respiratory distress with complete fixation of the left cord in adduction and almost complete fixation of the right cord. She died suddenly without tracheotomy. Sections of the larynx showed typical rheumatic involvement of the cricoarytenoid joint.

They report another case of a man brought in dead after having suddenly collapsed. He was known to have had rheumatoid arthritis for 21 years, and the lungs and heart showed severe evidence of rheumatoid disease. The pathology of rheumatoid arthritis of the larynx and arytenoid cartilages is discussed.

PHARYNGEAL STRIDOR

Russo and Coin[22] readily admit the laryngeal stridor in an infant may be due to many congenital or acquired conditions. They report a case of an infant with laryngeal stridor, which they attributed to calcification of the hyoid, thyroid and tracheal cartilages. They dismissed the laryngeal examination with the statement that it was "negative" They fail to mention the status of the epiglottis, the corniculate and cuneiform cartilages or the appearance of the mucosa covering the arytenoid area, all of which are vitally important in the evaluation of laryngeal stridor Little information on the results of examination seven years later is given to compare with the condition found in the first year. The diagnosis was chondrodystrophy calcificans congenita, a condition which rarely occurs in the larynx

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LARYNGOCELE

In a most interesting and informative article, Lane and associates[25] tell us that Virchow first described a laryngocele as a cystic dilatation of the sacculus or appendix of the ventricle of Morgagni. Larrey observed that many of the men reciting prayers from the temple minarets were afflicted with tumors of the neck. Later it was determined that abnormal increase of the intralaryngeal air pressure, such as in coughing, singing, playing wind instruments and glass blowing, distends the sacculus producing a laryngocele. To the 96 cases of laryngocele reported in the literature Lane and associates add a case of internal-external laryngocele. The surgical technique for correction of this lesion is well described. When removed, the sac measured 7 by 4 cm., and the patient made an uneventful recovery.

Sabri[26] reports a case of a combined internal-external laryngocele which was successfully removed by the one stage surgical procedure first suggested by O'Keefe. The laryngocele, which measured 5 by 2 cm. was hour-glass shaped.

Burke and Golden[27] report a case of external ventricular laryngocele and review the literature on this subject. They estimate that about 80 cases have been reported, although few of these appeared in the radiologic literature. Laryngoceles have been classified into internal, external or a combination of these. The roentgenographic appearance of these lesions is so classic that they present no problem in differential diagnosis. Bronchial cleft cysts, enlarged lymph nodes and laryngeal tumors are easily eliminated. Lateral pharyngeal diverticula may present a similar roentgenographic picture but are higher and usually smaller.

FOREIGN BODY

Spector[28] and Bautista report a case of an open safety pin lying in the trachea lodged between the vocal cords of a boy nine-months-old This foreign body had remained in place for almost ten days because the parents gave no history of foreign body inhalation It was discovered on routine roentgenography after the infant was admitted to the hospital The case is presented to emphasize the fact that the possibility of foreign body must be considered in children in whom symptoms referable to the respiratory tract develop

PARALYSIS

Laryngeal paralysis after spontaneous pneumothorax rarely occurs Such a phenomenon has occasionally been observed after artificial pneumothorax Palmer and Gupta[29] report a case of a patient experiencing simultaneously spontaneous pneumothorax and left recurrent laryngeal paralysis Two possible explanations offered for this are damage to the nerve due to a slight and subclinical mediastinal shift and ischemic injury to the nerve.

Marin[30] presents a contribution to the surgical management of laryngeal paralysis after thyroidectomy, which is rather difficult to understand in spite of reading and re-reading The presentation has probably suffered by translation Marin is principally concerned with unilateral paralysis after thyroidectomy with fixation of the cord away from the median line, resulting in poor vocal function Apparently the contribution offered by Marin has not been proved by trial and error and simply represents a theory, for he states, "we have imagined a procedure of cordal autoplasty formed of the following stages." He suggested making an incision in the thyroid cartilage, creating a window at the level of the paralyzed cord and inserting a piece of cartilage from the superior portion of thyroid into the window, forcing the paralyzed cord toward the median line and thereby closing the space between the cords with resultant improvement in phonation No cases are reported, because there were none to report There may fectively combats spastic closure of the glottis Injection of 1 cc of a one per cent solution of Pontocaine directly through the cricothyroid membrane is usually successful in stimulating a powerful reflex These and many other suggestions are offered to combat a condition, which, unless relieved promptly may produce serious consequences

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Gross[35] describes an illuminated laryngoscopic speculum for use on small animals It is self-retaining and combines the function of mouth gag and tongue depressor With the speculum in position the vocal cords are easily visualized, and intratracheal manipulations are readily accomplished

Bizzarri and Giuffrida[36] designed a laryngoscope blade which they believe is superior to the MacIntosh laryngoscope It does not have a vertical component, which they have found interferes with performance of laryngoscopy, particularly in patients with deformities of the head and neck

Miles Foxen[37] presents a modification of the usual types of intratracheal tubes used by the anesthetist Because of the possibility of detaching fragments of tumor and the implantation of malignant cells in the tracheobronchial tree, he designed a new type of intratracheal tube having a rounded tip and two small cuffs which he claims will produce less trauma in malignant tumors of the larynx

ANESTHETIZATION

Young[38] lists the conditions required during direct laryngoscopy and minor operations on the larynx as anesthesia readily terminated to minimize postoperative aspiration of blood or debris, complete relaxation of the jaw and cords, quickly reversible to allow assessment of the function of these latter, maintenance of airway even past fallen tongue and stenosed larynx, maintenance of tidal exchange even when positive pressure cannot be applied, and freedom from explosion

To meet these requirements Young gave minimal barbiturates intravenously Through an indwelling needle the patient was paralyzed by administration of a short acting relaxant A thin polythene or other catheter was then passed through the mouth and glottis to the carina, and then connected to a source of oxygen Further doses of relaxant were then given be merit to the theory, but until successful cases are reported it still remains just a theory

The Semon lecture for 1957 was delivered by Capps,[31] who talked on abductor paralysis in theory and practice since Semon This excellent, comprehensive article comments on the statement made by Semon "That in all progressive organic lesions of the centres or trunks of motor laryngeal nerves the abductors of the vocal cords succumb much earlier than the adductors" A diversity of opinion still exists relative to this statement Experimental works of, and reports by, laryngologists are quoted freely, and the anatomy and functions of the superior and recurrent laryngeal nerves are discussed The causes of unilateral and bilateral abductor paralysis are reviewed and the methods of treatment considered This is an excellent and informative article on a controversial subject

Chiong and Gorman[32] report 15 cases of bilateral abductor paralysis of the vocal cords after thyroidectomy which were corrected by external arytenoidectomy All were females The technique used was the Woodman modification of the Kelly operation, which is adequately described Results were successful with a good airway and a fair voice in all patients

In a lengthy discussion of vocal rehabilitation of paralytic dysphonia Arnold[33] emphatically states that paralytic dysphonia depends on several specific factors which he enumerates The type and degree of vocal disability due to laryngeal paralysis are extremely variable He discusses the various types of paralysis, and much consideration is given the median and paramedian positions of the paralyzed vocal cord In an analysis of the phonetic signs of paralytic dysphonia the single vocal qualities are discussed and followed through the five stages outlined in the discussion of laryngeal paralysis This most excellent paper must be read and reread to be fully appreciated

INSTRUMENTS

Lewy[34] presents a revision of the "one side open" laryngoscope originally described by Bruening, Mosher, Ingals and article on induction of anesthesia for laryngectomy In the preparation of this article they reviewed the management of anesthetization of 1000 patients subjected to laryngectomy The main concern of the anesthesiologist during laryngectomy is to maintain an unobstructed airway at all times This is not always easy, as the growth within the larynx may interfere with the airway, and the surgeon, working as he must on the airway, adds to the worries of the anesthesiologist The technique of inducing such anesthesia and the complications that might occur are discussed It is regrettable, however, that they did not discuss the possibilities of transplanting a piece of fragile carcinomatous tissue by the passage of a tube through the larynx into the lower trachea

Baillie and associates[12] report their experiences with induced hypothermia in five patients having major surgical procedures on the larynx The procedure considered for induced hypothermia was pharyngolaryngeal resection with block dissection as required and one stage reconstruction when possible Preoperative assessment was necessary in each patient The technique of anesthetization is well described Use of hypothermia in these five patients was highly successful Recovery from anesthesia and restoration of protective reflexes were rapid, and postoperative vomiting did not occur, however, these authors point out the danger of induced hypothermia, and they have been impressed by the excellent condition of the patients during and after the extensive operations performed

Hirzel[13] notes that early in surgical training, stress is placed on avoidance of injury to the inferior laryngeal nerve, but no emphasis is placed on avoiding injury to the superior laryngeal nerve If the entire superior laryngeal nerve is traumatized, deglutition, especially of liquids, is disturbed, and a persistent cough, shallow voice and fatiguing speech will result Trauma of the internal branch alone results in persistent post deglutition cough, but speech is normal Injury to the external branch results in a shallow voice which is easily fatigued, but there is no cough

Eight cases are reported of injury to one or the other as required Cardiac irregularities occur but apparently have caused no concern

Wolfson[39] presents a most interesting discussion of major and minor laryngeal sequelae of endotracheal intubation Major complications are uncommon The most commonly reported laryngeal complication of intubation is formation of granulomas Usually these occur at the vocal process where the mucoperichondrium covering this area is extremely thin Frequently, it is necessary to remove these granulomas surgically Wolfson quotes various authors who have reported complications The minor complications consist of post-intubation sore throat, laryngitis and tracheitis, which all respond favorably to proper therapy

Barton[40] believes that the fact that laryngeal granuloma may occasionally occur as a sequel to endotracheal intubation in no way invalidates the many advantages of this technique of induction of anesthesia, nevertheless, claims of negligence with resultant law suits are sometimes filed, even when the patient has completely recovered from such a granuloma

The etiology of these granulomas is discussed Barton believes that the proper method to handle these lesions is to allow a well defined pedicle to develop, after which self amputation will follow Although this is an excellent method, it frequently requires many months for the pedicle to form, and in the interim the patient is extremely hoarse We have obtained excellent results by surgical removal Barton is of the opinion that litigation over laryngeal granulomas due to intubation could be avoided if the anesthesiologist would see the patient before and after operation to evaluate his condition and to discuss possible complications with him He believes that the laryngologist can help by judicious treatment and by explaining to the patient that development of these granulomas does not signify negligence

Total or partial removal of the larynx is seldom performed in a general hospital, consequently, few anesthesiologists have wide experience with the problems and complications encountered in anesthetizing patients for this type of operation, according to Boyan and Howland,[41] who present an excellent

Postoperative endoscopy with the tracheal catheter, and when this fails, the bronchoscope, may be helpful. Tracheotomy under certain conditions may be lifesaving in removing secretions. The patient should be educated preoperatively to cough so that a well established cough mechanism is maintained postoperatively.

Norris[46] describes a new surgical procedure designated as "fronto-lateral partial laryngectomy." The indications for this procedure are those few lesions thought to be slightly too extensive for the laryngofissure operation and yet not sufficiently extensive to warrant total laryngectomy. The technique is adequately described in steps with illustrations, and 16 cases are reported. Although this technique has much merit, it is thought that the judicious selection of proper cases for its use poses a problem for all but the experienced laryngologist.

In an interesting article Cowan and McDougall[47] report nine cases of reconstruction of the pharynx after laryngo-pharyngo-esophagectomy successfully accomplished by their technique. In the treatment of carcinoma of the hypopharynx and extrinsic larynx they advocate excising the pharynx, larynx and cervical esophagus combined with hemithyroidectomy and radical neck dissection on the side of the neck over which the primary lesion centers. This creates a defect in the continuity of the pharynx from above the level of the hyoid bone to the lower cervical esophagus. The problem presented is closure of the defect, and the nine cases reported illustrate the technique employed in obtaining closure.

In discussing the factors which might contribute to the success or failure of the rehabilitation of the laryngectomized patient, Stoll[48] agrees with Schall that the psychological attitude of the patient plays a dominant role. The anxiety of the patient indicates the need for psychological adjustment, and when these factors are controlled, rehabilitation will be achieved more readily.

In a survey of 440 laryngectomized patients Putney[49] found that a useful buccal voice had failed to develop in 166. No underlying anatomic or physiologic factor was found to ac-branches or to the common nerve with symptoms Injury to this nerve should be stressed more in texts and surgical teaching

Schobinger[44] showed that spasm of the cricopharyngeal muscle after laryngectomy is frequently the cause of dysphagia He was able to obtain definite roentgenographic evidence of spasm of the cricopharyngeal muscle in a number of patients Symptoms ranged from mild discomfort to severe dysphagia Repeated esophageal dilations corrected the condition in some, and in others administration of a short-acting curare-like agent provided relief

Graham and associates[45] discuss the importance of removal of accumulated secretions from the tracheobronchial tree throughout the entire postoperative period If the patient cannot adequately eliminate these by coughing, he must be assisted by pharmacologic, physical and mechanical means or a combination of these

Bronchial secretions arise from goblet cells and tuboalveolar glands The thinner covers the membrane, the thicker faces the bronchial lumen This blanket of bronchial secretions is moved continuously from the smaller bronchioles to the larynx This is motivated by ciliary action, bronchial peristalsis, changes in bronchial contour and cough Bronchial plugging is due to a combination of factors in the postoperative period These are diminished bronchial calibre due to spasm and edema of the membrane, reduced respiratory excursion, ineffective effort to cough when coughing is painful, depression of ciliary activity and bronchial peristalsis, and excessive tenacious secretions

Preventive treatment consists of avoidance of operation in elective cases in the face of infection in the upper respiratory tract, abstinence from tobacco for two weeks before operation in heavy smokers, bronchial cleansing for three days preoperatively with bronchial dilators, such as epinephrine or similar products as nebulizers, linguets or suppositories, detergents as Alevaire and Tergemist, and humidification

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count for this failure, and patients with extensive surgical procedures including radical neck dissection were able to talk expertly A disturbance of the musculature of the tongue and floor of the mouth presented problems in swallowing and phonating Putney emphasizes that the primary object in treatment of carcinoma of the larynx is complete eradication of the lesion, and this should be carried out regardless of the sacrifice of tissue and heedless of the subsequent development of a voice Failure to develop a voice after laryngectomy is attributed to lack of energy, fortitude or desire to learn a new method

Norris[50] discusses the deformities, complications and disabilities resulting from laryngectomy with or without neck dissection These depend entirely on the extent of the surgical excision necessary to eradicate the malignant lesion Section of the spinal accessory nerves will always result in loss of trapezius function, and stenosis of the tracheal stoma, hypopharynx and esophagus always presents problems The management of these and other conditions is clearly and concisely discussed

Moses[51] is of the opinion that the voice of the laryngectomized patient has been much discussed, but the part of the voice therapist in the rehabilitation of the patient has never been outlined He, therefore, discusses the qualifications that are desirable in such teachers There is much need for psychological guidance for the laryngectomized patient, and the vocal therapist occupies a position in which such therapy can be properly dispensed Moses expresses his interest in the technique of teaching the esophageal voice and who should provide voice therapy The ideal treatment will be the joined forces of surgeons and medical therapists who are able to do more than just teach the patient to belch esthetically

Conley and associates[52] present a new surgical technique for vocal improvement of the laryngectomized patient This cleverly conceived operative procedure consists of creating a tunnel through the wall of the cervical esophagus and thereby establishing a controlled communication between the trachea and the esophagus This tunnel may be constructed of esophageal mucosa or a properly selected vein graft The latter is much easier to use than esophageal mucosa This tube is constructed in such a manner that air can pass into the esophagus without the disadvantage of food and saliva passing onto the neck or into the trachea This intriguing procedure was performed on 15 patients with only minor complications The authors believe that their results warrant further investigation of this procedure, which facilitates development of esophageal speech

In discussing the functions of the larynx Bautista[illegible] states that phonation is a purely social function Loss of the larynx thus produces a grave psychosocial crisis the significance of which can be fully appreciated if we thoroughly understand the primary place that communication holds in our psychologic and social health Rehabilitation of the laryngectomee should start approximately two weeks after operation if complete healing has occurred Bautista discusses the several methods of teaching new speech as advocated by speech therapists, and concludes that the esophageal voice remains superior to other types

Approximately one-third of all laryngectomized patients find it impossible, for one reason or another, to master esophageal speech These patients are in dire need of some type of artificial larynx in order to communicate vocally Barney[54] discusses the requirements of an ideal artificial larynx He believes that with the tremendous advances in electronics an acceptable artificial larynx will soon be developed Currently available speech aids are not too satisfactory, and with improved surgical techniques, plus the help of electronics the ideal will be achieved

Struben and Gelder[illegible] emphasize the fact that closure of the nasopharynx by action of the soft palate is essential for good intelligible speech It is necessary for the laryngectomized patient to make optimum use of the available volume of air collected in the upper portion of the esophagus The patient will start by closing the nasopharynx, as only in this way will he be able to bring air into the upper esophagus The nasopharynx opens for a very short time only to pronounce the nasal sound and immediately closes again to prevent unnecessary loss of air In order to obtain a clear voice and intelligible speech an excellent functioning of the mechanism of the upper esophagus with pseudoglottis is necessary

BENIGN TUMORS

Multiple papillomatosis of the larynx remains one of the most vexing problems facing laryngologists today Pinsker and Proud[56] conducted studies which made them agree with the opinion expressed by virologists that the various papillomas that plague mankind are caused by similar, if not identical, viruses This virus etiology of laryngeal papillomas was established by Ullman in 1923 Several definite characteristics of the papilloma virus are recognized, and others are presumed This virus is infectious, but to a slow degree It stimulates an antibody response over an extended period of time The major reaction of the infected individual is local This would certainly explain the extended course of the disease for many years, and finally the spontaneous remission, which is most frequently the outcome Pinsker and Proud believe that topical application of podophyllin is beneficial when multiple papillomas are removed surgically, although we question its value.

Winston and Epstein[57] made a systematic study of benign laryngeal tumors based on recent material seen at the Royal National Throat, Nose and Ear Hospital in London In this, the third and final part of the study, they record the incidence of the condition and assess its clinicopathologic implications with particular reference to the problem of malignant change They found that the papilloma was the commonest benign laryngeal neoplasm Of 39 cases encountered between 1948 and 1957, eight were in children and 31 in adults Their cases substantiate the observation of others that the evidence for the alleged regression of these neoplasms at puberty is tenuous They believe that the importance of diet as an etiologic factor has been underestimated Prophylactic tracheotomy is advocated in an attempt to prevent fatal asphyxia in children with laryngeal papillomas, which they point out is a real possibility The importance of careful assessment of the histology of adult papillomas in order to detect malignant changes early is emphasized Such changes occurred in one of their 39 cases

Hinton and Weinberger[58] report a case of granular cell myoblastoma of the larynx found while investigating the complaint of hoarseness due to vocal nodules At that time a nodular mass was seen on the superior surface of the left ventricular band and biopsy established the diagnosis When completely removed, granular cell myoblastoma of the larynx seems to have little predilection for recurrence The exact origin of this type of tumor remains obscure

Campbell and associates[59] present five cases of congenital subglottic hemangioma and review 14 previously reported cases All 19 patients were younger than one year old and showed evidence of laryngeal obstruction, which was usually episodic and sufficiently severe to require tracheotomy The diagnosis was made in most cases by detection of subglottic stenosis by roentgenographic, laryngoscopic or bronchoscopic examinations Noisy respiration or wheezing, episodes of severe dyspnea and stridor, working of accessory muscles, sternal retraction and cyanosis should suggest the possibility of congenital subglottic hemangioma Tracheotomy should be done early Roentgenotherapy produced clinical improvement in four of the five cases in which it was used This is an excellent and illuminating article which should be read by all laryngologists, as too often we fail to consider subglottic hemangiomas as possible factors in laryngeal obstruction

Som[60] reports an interesting case of a 47-year-old man who complained of hoarseness of one month's duration On indirect laryngoscopy a broad based mass was seen attached to the left arytenoid, covered by intact mucosa The pyriform fossa was obliterated, but motility of the vocal cords was not impaired and there was no cervical adenopathy Tomography of the larynx demonstrated a soft tissue mass occluding the left pyriform fossa and involving the left arytenoid region The true and false cords were displaced medially, and the ventricle was obliterated

Lateral pharyngotomy was performed, and the tumor was removed. Eight months later the patient returned with practically the same findings as originally. A more radical operation was employed, and not only was the tumor removed, but the major portion of the epiglottis was also removed in continuity. The diagnosis was neurofibroma of the larynx.

Handousa and Elwi[61] describe scleroma as a disease characterized by chronic specific inflammatory lesions of the upper respiratory tract. Their studies of the histopathology of scleroma are interesting. They are of the opinion that the vacuolated or foamy appearance of Mickulicz cells is due to hydropic degeneration. It is well known that the diffuse or nodular form of scleroma is usually bilateral. The authors, however, report cases of scleroma which were manifested by a single large mass like a tumor. Laryngeal scleroma, according to Handousa and Elwi, is almost always secondary to nasal scleroma. The site of choice is in the "subglottic region" and eventually a fibrous stricture forms. Unilateral involvement of the ventricle and thickening and fixation of one cord are seen occasionally with or without a granuloma. The clinical appearance of these cases closely simulates malignant disease.

The encountering of a thyroid tumor in the larynx and trachea of one of his patients prompted Waggoner[62] to review the embryology and theories of pathogenesis. He concluded that non-malignant thyroid tissue found inside of the larynx or trachea must arise by direct extension from the thyroid gland or from deposits of thyroid tissue early in embryonic development. Development of obstruction of the airway will depend upon the size of the tumor, which is usually located on the posterior wall, and suspicion that the tumor is thyroid tissue is strengthened if an external goiter is present. Surgical removal is indicated. Waggoner points out that intralaryngotracheal goiter, although rare, should be kept in mind when making a diagnosis of intralaryngeal tumors. A tracer study with radioactive iodine is an important adjunct to diagnosis and will frequently help direct the proper course of treatment.

Pickard[63] reports two cases in which leiomyomas of the larynx occurred in close proximity to the airway He stated that the tumors arose from and were formed of the fusiform nucleated cells of involuntary muscle He was able to find only one report of a leiomyoma in the trachea in the literature, and of 106 benign tumors of the larynx at King's College Hospital, only one was a leiomyoma

MALIGNANT TUMORS

In a most excellent monograph on clinical and surgical problems of cancer of the larynx and hypopharynx, Pietrantoni and Fior[64] analyze the different aspects of this problem Greatest importance is given to classification according to stage and site Tobacco and alcohol are considered etiologic factors, and a study of 200 cases showed that smoking might well be considered as a possible cancerogenetic factor Only a local irritative action may be attributed to alcohol, as shown by the prevalence of pharyngolaryngeal tumors in the group of heavy drinkers The higher clinical malignant growth of poorly differentiated and basal cell carcinomas is stressed, these should be treated with radical excision combined with elective neck dissection Hypopharyngeal cancer is much more frequent in Great Britain, France and Scandinavia than in Italy The prognosis is better in women than in men Pietrantoni and Fior state that laryngectomy with combined neck dissection shows no higher operative risks than laryngectomy alone, and to prevent shoulder drop and other undesirable sequela, the spinal accessory nerve is dissected free when possible They believe that every surgical technique will give satisfactory results, providing they have a well defined anatomic foundation, permit total removal of the tumor, and postoperative complications are held to a minimum Hemilaryngectomies have been abandoned in the belief that laryngectomies offer greater chance of survival Irradiation therapy after laryngectomy is advocated The curability of laryngeal carcinoma depends largely on whether cervical metastasis is present This article represents one of the best reviewed this year and should be thoroughly read to be appreciated

Work[65] classifies cancer of the larynx and pharynx according to the International Radiological Congress' proposals made in Copenhagen in 1953 into cordal, supraglottic, subglottic, hypopharyngeal and postcricoid. Size, presence of edema, surface growth and deep ulceration, as well as grading in stages from I to IV, may be of further assistance in classification. The diagnosis can usually be made by biopsy and microscopic examination. Papanicolaou's stain of extruded cells, tomography, contrast roentgenography and palpation are other aids in establishing the diagnosis. Surgical removal and radiation are the only two forms of therapy available today for the treatment of cancer of the larynx. The classification of the lesion, its site, type and extent, and the indicated therapy are given.

Barretto[66] presents suggestions for the nomenclature and classification by staging of malignant tumors of the larynx and hypopharynx. There has been an urgent need for a uniform nomenclature and staging of malignant tumors of the larynx, and this presentation by Barretto shows that much effort has been directed toward an attempt to present a plan that could be universally accepted. The very fact that a nationally recognized group has recently appointed a committee to study and present suggestions and plans on this subject proves that no plan has as yet been accepted by laryngologists. Work such as Barretto has presented will undoubtedly contribute much help to the newly formed committee.

Hall[67] correctly states that sarcoma of the larynx is a rare condition, occurring in from 0.5 to 1 per cent of all malignant laryngeal tumors. Such a case is reported involving the entire right vocal cord, and on histologic examination of a specimen obtained at biopsy, a spindle cell sarcoma was noted. These tumors have a tendency to be smooth and possibly lobulated, and do not ulcerate in the early stages. Metastasis occurs late. The prognosis is probably more favorable than is that of carcinoma of the larynx. In the case reported, the early results of radiation therapy appeared to be excellent, but recurrence was early and rapid, and the thought is expressed that surgical removal is the most effective treatment.

Seyfried[68] believes that selection of therapy in carcinoma of the larynx is best arrived at by the combined efforts of the radiologist and the laryngologist We do not agree with his statement that the laryngologist cannot make an accurate diagnosis of cancer of the larynx without the help of the radiologist Seyfried states that glottic tumors involving only one cord and without impairment of mobility were formerly treated by laryngofissure He offers no reports of cases to substantiate his statement that these lesions will now regress completely with fractional Roentgen-ray therapy He points out that laryngofissure can now be employed to remove tumors of wider extent if associated with an inflammatory process, or if recurrent The indications for the laryngofissure operation are well outlined Extensive tumors as a rule will not respond favorably to such a conservative procedure, and the same applies to recurrences after initial Roentgen-ray therapy There are many controversial problems in this article and many that are unacceptable to the reviewers

Sarma[69] presents a study of the incidence and etiology of cancer of the larynx in Assam, the easternmost state of India It is astounding to read that during the period from October, 1948, to December, 1951, 351 cases of cancer were diagnosed at the Assam Medical College Hospital, of which 186 were in the larynx, an incidence of 50 per cent A survey conducted from January, 1954, to March, 1955, showed 238 cases of cancer of the upper alimentary tract, as against 84 cases in other parts of the body Of these, 108 were found in the larynx In Assam, of 220 cases of cancer of the larynx reported, 217 were extrinsic and only three intrinsic Sarma attributes the high incidence of carcinoma of the larynx in Assam to the prevalence of chewing the betal-nut, which produces violent irritation of the pharyngeal mucosa, particularly in the region of the pyriform fossa

Putney[70] states that when carcinoma attacks portions of the larynx other than the vocal cords, metastasis to the regional lymph nodes occurs frequently Recognition of this fact and performance of block dissection of the neck may help prevent loss of life from undetected lymphatic metastasis In this most excellent article, Putney reports that in 223 cases of carcinoma of the larynx in which 236 dissections of the neck were performed, the incidence of carcinoma in the cervical lymph nodes was 56 per cent The highest percentage of regional lymph node metastasis occurred in extensive laryngeal lesions or those involving the arytenoid, aryepiglottic fold, pyriform fossa or vallecula Preventive dissection of the neck was performed in 62 patients with no palpable lymph nodes, in 16 (26 per cent) of whom cancer was histologically present in the excised lymph nodes Putney rightfully concludes that dissection of the neck at the time of laryngectomy, in patients with laryngeal carcinoma involving areas besides the vocal cords, will result in more five-year survivals The curability of cancer is highest when there is no metastasis, less with microscopic metastasis and least when palpable metastatic glands are present All interested in carcinoma of the larynx should read this article in its entirety

Rubenstein and associates[71] report two cases of carcinoma of the larynx associated with carcinoma of the bronchus They emphasize the fact that patients who have carcinoma of the larynx should be observed carefully for the appearance of carcinoma of the lung Multiple primary neoplasms are by no means rare Warren and Gates are cited as considering the tendency for a second cancer to develop in a person to be 11 times greater than that of the patient who has never had cancer When two carcinomas are discovered simultaneously, the more lethal lesion should be attacked first

In carcinoma of the epiglottis Ogura[72] wonders whether the tremendous sacrifice of total laryngectomy with commission of the patient to permanent tracheostomy is entirely necessary He points out that the aims of the surgeon are not only adequate removal of the lesion but also preservation of the laryngeal physiologic relationships In an attempt to conserve the function of the larynx, supraglottic subtotal laryngectomy and radical neck dissection as a one-stage operation for carcinoma of the epiglottis was developed

The 11 surgical criteria for this procedure are listed and the technique is described Neck dissection is carried out on the same side as the growth, even in the absence of nodes

Deglutition becomes a serious problem that requires time to master

En bloc removal of the primary lesion together with radical neck dissection was performed on 15 patients Early rehabilitation of the patient has been accomplished by reconstruction of the laryngopharynx by a muscle flap and skin graft It is possible to preserve the function of the true cord

Mitchell and Haybittle[73] made a study of the results of treatment of 130 cases of squamous carcinoma of the skin, 44 cases of carcinoma of the larynx, and 104 cases of carcinoma of the pharynx in an attempt to assess the dose levels to be used with radio-iridium, 192^{Ir} γ-ray therapy The clinical results did not provide any conclusive evidence that in the treatment of carcinoma of the larynx and pharynx the use of a short distance X-ray therapy unit instead of the conventional Roentgen-ray apparatus leads to a higher cure rate

Marchetta and co-authors[74] report their experiences with 270 cases of carcinoma of the extrinsic larynx Of these patients, 241 were treated with radiation between 1935 and 1953, 63 had extrinsic cord lesions, 88 lesions of the epiglottis and 90 involvement of the arytenoid and aryepiglottic folds At the end of 24 months, 78 per cent of the patients were dead of the disease, and 14 per cent showed no evidence of disease After reviewing these results Marchetta and associates considered the treatment of choice to be surgical Laryngectomy was performed on 14 patients and laryngectomy and neck dissection on 15 patients Because of histologically positive nodes in 60 per cent of surgical specimens, total laryngectomy and radical neck dissection were adopted as basic therapy for all patients with carcinoma of the extrinsic larynx The cure rate in the 29 patients who had radical surgical excision was 45 per cent, this is a definite improvement over former results

Sixty-two intrinsic laryngeal carcinomas were removed through the thyrotomy approach, were serially sectioned and were examined by Multanen[75] The following points were considered metastasis, recurrence, rate of tumor growth, the patient's age and duration of survival after treatment

In 12 of the 62 cases the histologic picture varied in different parts of the malignant tumor Greater variations were noted in the posterior part than in the anterior part In general, the degree of malignant degeneration was the same at the periphery as in the center This study also substantiated the known fact that the more histologically malignant the lesion the greater the number of mitotic figures Tumors that metastasized later showed originally a higher percentage of mitotic figures

Comparison of tumors of the vocal cord with those of the ventricular band showed that those that metastasized later had the same increase in mitotic figures—in other words, a higher degree of malignant degeneration

Carcinoma of the larynx is a disease of old people Those younger than 50 years showed a higher degree of malignant growth than those older than 50

Inflammatory cells are regarded as a typical feature of malignant growth No conclusions could be drawn as to their effect on the cytology of cancer of the larynx

Jesberg[76] expresses concern as to what happens to laryngectomized patients in whom the disease later extends to the cervical lymph nodes Metastatic cervical lymph node disease develops in approximately 30 per cent of laryngectomized patients Improvement could be expected by performing neck dissection at the time of laryngectomy, but the difficulty is in selecting the cases for such an extensive operation Jesberg quotes a statistical report by Kuhn, who stated that 57 per cent of all non-cordal and diffuse growths were complicated by metastatic lymph node disease The element of unpredictability in the biological behavior of these growths is impressive One patient may have a bulky, primary, extracordal growth without metastasis, and another with a small cordal lesion may eventually manifest incurable metastatic disease Jesberg discusses the clinical types of lymph node metastasis and reports two cases of contralateral metastasis after laryngectomy In the discussion of contralateral metastasis, Willis offers a pathologic explanation based on the disturbed dynamics of the lymphatic drainage system in the presence of neoplastic disease

In an interesting article, Hladky and Spindrich[27] compare the results of treatment of patients suffering from cancer of the larynx during the decade 1945 to 1954, with those obtained during the foregoing decade Patients were treated with irradiation according to the Coutard technique, by surgical extirpation, or by both methods Although Hladky and Spindrich are enthusiastic about the results obtained with irradiation, this enthusiasm is not warranted, as the percentage of five and ten-year survival is much higher in patients treated surgically Hladky and Spindrich contend that the advantage of surgical treatment consists in its being independent of the varying degree of radiosensitivity of tumors, whereas successful irradiation depends entirely upon the sensitivity of neoplastic cells toward irradiation, therefore, frequent laryngoscopic examinations are imperative for all patients treated by irradiation

Hagan[28] advocates prompt, aggressive surgical treatment in all operative cases of laryngopharyngeal cancer Surgical resection of these tumors is not only feasible, but until better methods for the treatment of cancer are discovered, offers the best chance of obtaining a cure

Fisher and Miller[29] present a ten year study of the histopathologic classification, prognosis and treatment of 48 cases of carcinoma *in situ* of the larynx The average age of the 41 males was 55 years, and of the seven females, 44 years

All were proved cases of carcinoma *in situ* histopathologically, without invasive carcinoma when the diagnosis was first made There is no typical clinical change, leukoplakia being the most common, but one case showed typical vocal nodules, two cases exhibited polypoid changes of hypertrophic laryngitis, and three cases showed typical contact ulcer granulomas

Histologically, there were three types the squamous type, the basal type and the Bowenoid type The squamous type was associated with leukoplakia, the basal type, with lesions

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of the swollen injected variety without leukoplakia When the clinical picture was mixed, the histological picture was also mixed

The type of treatment depended on the extent of the lesion, method of original diagnosis, and development of recurrence

Leukoplakic lesions were completely stripped for diagnosis If the lesion was small and completely stripped, no further treatment was instituted If residual or recurrent carcinoma was proved in the same lesion, laryngofissure operation was performed If carcinoma *in situ* was found in extensive leukoplakia, complete stripping was performed The non-leukoplakic lesions were handled in the same way, but more often extensive roentgenotherapy was employed

Of the 16 patients treated by stripping only, invasive carcinoma developed in four later Carcinoma has developed in none of the eight patients treated by laryngofissure Invasion occurred in six of 24 patients who had roentgenotherapy

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CYLINDROMAS OF THE UPPER DIGESTIVE AND RESPIRATORY PASSAGES—A CORRELATIVE STUDY OF THEIR HISTOLOGIC PATTERNS, CLINICAL FINDINGS AND MODES OF THERAPY*

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The cylindroma pattern of adenomatous tumors of the upper digestive and respiratory passages is a characteristic one that has been observed in tumors of the major salivary glands and those developing in the nose, paranasal sinuses, lips, mouth, pharynx, palate, tongue, larynx, trachea and bronchi Numerous reports in the literature indicate that, although the cylindroma type of glandular tumor may occur in the major salivary glands, it is more common in aberrant or ectopic sites Recent experience with three such tumors of almost identical microscopic appearance, in the nasal passages, tongue, and larynx respectively, make it seem of some value to report in more detail, further, their mode of spread is similar to that of a basal cell carcinoma with persistent tendency to recurrence in a slowly progressive destructive course A review of the histologic and clinical characteristics of such tumors indicates the need for early, aggressive, adequate treatment

In recent years, bronchial tumors, usually referred to as bronchial adenomas, have been diagnosed clinically with increasing frequency In 1930, Kramer[1] reported on the findings and treatment of two such cases, and was able to find only five cases reported in the literature Since that time many cases have been described A study of the histologic picture of bronchial adenoma reveals that some of these tumors have the characteristic pattern of cylindroma and may have a very different and more serious clinical course than

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AMERICAN ASSOCIATION FOR CLEFT PALATE REHABILITATION

The American Association for Cleft Palate Rehabilitation will hold its Eighteenth Annual Convention at the Brown Palace Hotel, Denver, Colo, Thursday, Friday and Saturday, May 12, 13 and 14, 1960

This Association is composed of medical, dental and paramedical specialists who are interested in the rehabilitation of persons with cleft lips and palates

mas was that of Billroth[16] in 1859 He reviewed the pathology and treatment of several cases of parotid tumors and originated the term "cylindroma" for one type of parotid tumor which to him appeared to consist of cylinders of mucoid stroma intertwined with the epithelial elements He described in some detail one case of recurrent parotid tumor observed over a period of 23 years, requiring nine operative procedures The tumor recurred and had all of the clinical characteristics of the cylindroma currently considered

For many years after Billroth's communication, cylindromas were described with reports of other mixed tumors of the major salivary glands, especially those of the parotid There was then much debate as to whether the cells in these tumors were of endothelial or epithelial origin Both Billroth and Virchow considered them to be essentially of mesenchymal origin and that the most common type was a fibromyosarcomatous variety They gave good descriptions of the mixed tumor but thought that they were of connective tissue origin Others considered them to be of endothelial origin from the vascular tissue in the salivary glands Ahlbom[17] has reviewed the early European literature and states that the endothelial hypothesis was reported by Kolaczek, 1878, Wartmann, 1880, and Volkmann, 1895 Still others thought that these tumors arose from mixed epithelial and mesenchymal structures and may have developed from an early, not yet differentiated embryonal anlage, the branchiogenic genesis first suggested by Cohnheim[18] in 1882

Koestler[19] in 1867, used the term "cancroids" in describing glandular tumors which he felt were the same as Billroth's cylindroma, and Waldeyer,[20] 1872, described parotid tumors as a mixed group of tumors and compared them with mixed tumors in other organs Minssen,[21] 1874, clearly applied the term "mixed tumors" in a review entitled "Mixed Tumors of the Parotid," and the term has been in general use since that time

The first to express the opinion that mixed salivary gland tumors were epithelial in origin was Von Bruns, in 1859 Malassez,[22] 1883, in reviewing many reports was able to find 11 synonyms for what he considered were cylindromas and that of the usual "adenoma". The histologic pattern and clinical course of these tumors have, therefore, been included in this study, because of their apparent relationship to other tumors arising in similar mucosa of the upper digestive and respiratory passages.

HISTORICAL REVIEW

The cylindromas are a group of tumors now considered by most authorities to be of epithelial origin probably arising from the epithelium of the ducts or acini of mucus glands. They are undoubtedly malignant tumors and have been described by Harrison[2] as "a most formidably lethal group", however, they were not always considered either malignant or of epithelial origin.

The cylindroma has received many different synonyms adenoid cystic carcinoma (Spies[3]), basalioma (Krompecher[4]), adenocarcinoma of the mixed tumor type (New[5]), and by others it has been compared to skin tumors of the epithelioma adenoides cysticum variety. The bronchial adenoma, in a similar fashion, has been described by various names in many reports over the years.

Many of the tumors reported as adenoma from the bronchus have been cylindromas, and only in recent years has this been clearly recognized. Some considered bronchial adenomas to be of mesodermal origin, while others considered them to be of epithelial origin. A brief history of the various names given to these tumors will serve to indicate some of the confusion in regard to their origin and nature. At various times these bronchial growths were known as sarcoma of alveolar pattern (Ephraim,[6] 1911), cylindrical cell carcinoma (Kreglinger,[7] 1913), basal cell cancer (Geipel,[8] 1931), benign bronchial adenomata (Wessler,[9] 1932), carcinoids (Kernan,[10] 1935), adenocarcinomas (Moersch,[11] 1935), benign glandular tumors (Clerf and Crawford,[12] 1936), vascular adenoma (Zamora and Schuster,[13] 1937), endotheliomas (Welt and Weinstein,[14] 1937), and mixed tumors of the lung (Womack and Graham,[15] 1938).

The earliest report of salivary gland adenomas and cylindroof glandular origin, one of which had the typical appearance of a cylindroma.

Despite an increasing weight of evidence favoring epithelial origin, there were some who felt otherwise. Wilson and Willis,[28] 1912, carefully studied many parotid tumors and concluded that "there was little evidence that these tumors arise from proliferating adult epithelium or endothelium. There is considerable evidence to support the theory that these tumors are mesotheliomas of embryonic origin."

Fry,[29] 1927, reported in detail on the histologic structure of mixed tumors after a study of 25 cases and stated conclusively that they were epithelial in origin. He felt that both the mucin and the "cartilage" in these tumors were products of the glandular epithelial cells. He stated that the tumors showed varying degrees of malignancy with no definite dividing line between innocent and malignant; furthermore, Fry believed some of the more malignant formations may demonstrate many of the features typical of the innocent type of tumor.

Brunschwig,[30] 1930, described the prolonged course of two patients with cylindroma of the tongue and sublingual region. He found that neoplasms of this type closely resemble basal cell or adenocystic carcinoma. He presented photographs of microscopic sections showing the classic cylindroma pattern.

Spies,[31] 1930, reported on adenoid cystic carcinoma of cutaneous and non-cutaneous origin, the latter from the maxillary sinus, nasal mucosa and salivary glands. There were 21 cases of non-cutaneous origin, and his illustrations again reveal a typical cylindroma pattern. Three patients had widespread metastasis, one of skin origin, one from the nasal cavity, and one from the submaxillary gland. Both Brunschwig and Spies suggest a characteristic histologic and clinical picture of the cylindroma type of tumor.

New and Childrey,[5] 1931, reported on a large series of cases of adenocarcinoma of the mixed tumor type occurring in the tonsil and pharynx. Bredlau,[32] 1934, and Weidlein,[33] 1936, each reported a single case of a salivary gland tumor of the supported the theory of their origin from epithelium He added two cases of his own, one from the palate and the other from the submaxillary regions Shortly afterward, Paget,[23] 1886, was one of the first to describe these adenomas in the palate and recognized that many of them resembled parotid mixed tumors Hinsberg,[24] 1899, made a painstaking histologic study of nine mixed tumors and criticized the endothelial theory He assumed that they started from embryonic rests of parotid anlage, and many observers afterward adopted his theory

From this period at the turn of the Century onward, there was increasing support for the theory of the epithelial origin of salivary gland tumors, both in the major salivary glands and in ectopic sites, although considerable support still persisted for their connective tissue origin Many tumors then called "sarcomas" would be classified otherwise at the present time In a summary of the early literature Ringertz[25] indicates the high percentage of sarcomas when he reported

Bosworth	1889	30 carcinomas	71 sarcomas
Finder	1896	47 carcinomas	100 sarcomas
Kummel	1900	40 carcinomas	69 sarcomas
Maljutin	1902	17 carcinomas	62 sarcomas

Ribbert,[26] 1907, strongly supported the epithelial theory He reviewed the histology of cylindromas in much detail and gave a clearer definition of the term His description indicates that the term cylindromas, or the cylindromatous tissue layers, involved both the epithelial structures and the mucoid supporting stroma

Krompecher,[4] 1918, studied not only a large group of salivary gland tumors but also many tumors originating in the skin and described them with the term "Basallzellenkrebs," or basal cell cancer He thought that both cylindromas and skin tumors were epithelial in origin, arising from the basal cell layer He referred to many cylindromas as "basaliomas" and described both solid and cystic subgroups Blumenfield,[27] in 1914, described two tumors of the lip which appeared to be of glandular origin, one of which had the typical appearance of a cylindroma

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Ahlbom,[17] 1935, reviewed 254 cases of mucous and salivary gland tumors He considered the cylindromas to be of epithelial origin and accepted Krompecher's[34] classification, calling them basaliomas. Those tumors having the appearance of a cylindroma, he referred to as basalioma with cylindromatous features Most of these tumors he considered semimalignant or frankly malignant

Harvey, Dawson and Innes,[35] 1938, reported their histologic review of a large series of salivary gland tumors They confirmed their epithelial origin but felt that the term cylindroma was a "misleading term for the actual microscopical appearances which are nevertheless characteristic" They felt it best to class them as adenomas but gave no follow-up record to indicate the clinical aspects of cylindromas

Ringertz,[25] 1938, in an excellent review of the pathology of malignant tumors of the nose, paranasal sinuses and maxilla, reported 37 cases of mixed gland tumors Like Ahlbom, he called those with a cylindromatous pattern, basaliomas He found two varieties the solid and the cystic His illustrations, too, reveal the typical cylindroma pattern

Kramer and Som,[36] 1939, reported six cases of cylindroma of the upper air passages They described the clinical features of these tumors and considered them locally malignant with distant metastasis rare

In 1942, Dockerty and Mayo[37] reported that 18 5 per cent of their series of 81 primary submaxillary gland tumors were adenocarcinoma of the cylindroma type They found these tumors to have pronounced infiltrating qualities and a high rate of recurrence Their illustrations demonstrate the typical cylindroma pattern

Mulligan,[38] in 1943, reported that a survey of the literature indicated that metastasis of salivary gland tumors was uncommon as compared with recurrences He reviewed 22 cases of such metastases Sixteen of these were either diagnosed cylindroma or adenocarcinoma, with a similar histologic picture His illustrations, like those of several preceding authors, demonstrate clearly adenocarcinoma and cylindroma

Hellwig,[39] 1945, advanced the interesting theory that salivary gland tumors, particularly those of the parotid, submaxillary region and palate, developed from notochordal tissue adjacent to the foregut region He felt that mixed tumors resembled the tissue of the adult nucleus pulposus

Bauer and Fox,[40] 1945, reviewed the histology of six cylindromatous tumors of the palate, and concluded that the myoepithelial basket cells surrounding the acinar epithelium made up the new growths They called the cylindromas adenomyoepitheliomas of the palatal mucous glands Sheldon, in 1943, had described similar cells in certain types of mixed salivary gland tumors

By this time there were sufficient reports from many clinics to indicate the similarity of many of these glandular tumors of epithelial origin having a cylindromatous pattern, further, the clinical significance of this histologic pattern became more impressive

Quattlebaum, Dockerty and Mayo,[41] 1946, reported that 10 per cent of a series of consecutive primary parotid neoplasms appeared to be adenocarcinomas of the cylindroma type

McDonald and Haven[42] reviewed 339 cases of malignant tumors of glandular nature in the nose, throat and mouth Eighty-six of these were classified as cylindromas, and 15 of the 86 evidenced metastases They stated that their study emphasized that one type of tumor, the cylindroma, "is a far more serious disease than generally recognized"

Pollock,[43] 1952, reported five cases of cylindroma of the nose and sinuses, considered them malignant tumors with a tendency to "relentless recurrence" Foote and Frazell,[44] 1953, studied over 500 tumors of the major salivary glands Their illustrations clearly demonstrate many cylindromas which they classify as adenoid cystic carcinoma

Russell,[45] 1955, reviewed a large series of adenomatous tumors of the anterior foregut region and suggested that the name cylindroma be accepted for this type of tumor, which she again reported has such a grave prognosis.

Harrison,[2] 1957, reported on 63 cases of salivary adenomas of the buccal cavity, 36 of which showed the cylindroma pattern. These tumors also followed a slowly progressive course with many recurrences, repeated and persistent local infiltration, and late metastasis.

Adenomatous tumors of the trachea and bronchi have been reported for many years. As was previously stated, a review of the many names applied to these tumors indicates the confusion which has existed as to their origin and histologic pattern. Kramer,[1] 1930, reported two cases treated bronchoscopically and called them adenoma of the bronchus. Fried,[41] 1934, reported a case which he considered benign. His illustrations suggest cylindroma. It was about this time that adenomas of the bronchus became more widely recognized. Jackson and Konzelmann,[17] 1937, reported 12 cases, one of which is illustrated, and appears to be a cylindroma. Kramer and Som,[36] 1939, reported three bronchial cylindromas among the six such tumors in the upper air passages and described the clinical features of these growths.

Brunn and Goldmann[18] reviewed 19 cases in 1941, crediting Wessler and Rabin, 1932, with giving a good earlier clinical description of the symptoms and findings of these tumors. By this time, however, they felt that surgery was the treatment of choice. Adams, Steiner and Bloch,[49] 1942, were among the first to recognize that there were two widely divergent schools of thought in regard to bronchial adenoma and its management. One group considered them benign, to be treated conservatively, while the other considered them as malignant, to be treated by wide surgical excision.

Clerf and Bucher,[50] 1942, reported 35 cases, some showing a cylindroma pattern. They did not, however, consider these bronchial tumors to be malignant and advised bronchoscopic removal unless they were not accessible. Laff and Neuberger,[51] 1944, reported two cases of bronchial adenoma with metastasis, and their illustrations definitely reveal cylindroma. Graham and Womack,[52] 1945, were aware of this inconsistent behavior of these tumors when they titled their report "The Problem of the So-called Bronchial Adenoma"

Harrington, Moersch and McDonald,[53] 1946, in a "Symposium on Certain Tumors of the Bronchi," clearly divided these tumors into two groups, namely, adenomas and cylindromas, the latter containing some mucin secretion Adenomas apparently were considered by some to be quite benign, had a uniform histologic picture and, in their opinion, a good prognosis Belsey and Valentine,[54] 1951, reported three cases of cylindroma and felt that they behaved as carcinomas of low grade malignancy Their photographs reveal a typical cylindroma with invasion of the perineural lymphatics Reid,[55] 1952, attempted to clarify the situation when he reported that bronchial adenoma really includes two groups of tumors *1* the more common, resembling carcinoid and having a benign course, *2* the other, which demonstrates the characteristic pattern identical with that of certain tumors of major and minor salivary glands It is most commonly described as cylindroma, mixed tumor or adenoid cystic carcinoma Among endoscopists and thoracic surgeons, there is now an awareness of the potentially malignant nature of certain bronchial tumors formerly considered benign Van Hazel, Holinger and Jensik[56] have reported a series of these cases and specifically attempt to differentiate between adenoma and cylindroma because the clinical behavior of these two tumors can be so different

REPORT OF CASES

Case 1 Mrs L Y a 67 year-old woman was first examined on Nov 12 1956 Six weeks earlier, her son-in law a dentist noted a small smooth swelling on the lateral margin of her tongue in the middle third while extracting a tooth On careful questioning there was no history of pain tenderness bleeding or any other symptoms The past history revealed that she had been in good general health She had pneumonia many years ago, however, without complications She was on no medication and never smoked There was no history of allergy or drug sensitivity

On discovery of the tumor mass excision biopsy was attempted by an oral surgeon who felt that it was not completely excised The biopsy was reported as cylindroma

Physical examination was carried out about four weeks after the biopsy which revealed essentially normal findings in the ears nose and throat There was a small slightly raised non tender firm scar at the biopsy site in the lateral margin of the middle third of the left side of the tongue The larynx and base of the tongue appeared clear but there was much lymphoid tissue at the tongue base bilaterally No cervical nodes or masses were palpable Chest and abdomen revealed no abnormal findings other than a well healed hysterectomy scar

Laboratory examinations revealed the urine negative for sugar and albumin, with a S G of 1,020, w b c 9600, hb, 85 per cent or 13 2 gms, hematocrit, 43 per cent Normal differential count Wasserman negative Chest X ray normal findings EKG showed a sinus rhythm with findings suggestive of mild coronary insufficiency

There was no contraindication to surgery or general anesthesia, so on Dec 6, 1956, under general anesthesia, the scarred area and residual tumor were widely excised by a wedge excision The postoperative course was uneventful, and there has been no evidence of recurrence to date

Pathology report moderately well differentiated adenocarcinoma (cylindromatous type)

Case 2 Mrs M O, a 39-year old housewife, was first seen on Sept 6, 1956 She had been treated two months earlier for severe nasal bleeding from the left side of her nose When this was controlled, a smooth mass in that side of the nose was biopsied, revealing a malignant growth The patient had a long history of "sinus congestion" on the left side over a period of many years Colds always seemed to settle in the left cheek and beneath the left eye There had been some nasal discharge of varying character, sometimes a sudden outpouring of watery material Her general health had been good She had a sensitivity to ragweed and had been given allergy "shots" regularly for seven or eight years

Physical examination revealed a large, vascular, smooth mass filling the left side of the nose, apparently originating above the middle turbinate and extending down to the floor The mouth and pharynx were normal In the nasopharynx the left choana was blocked by the mass, but there was no extension of it to the vault or lateral wall The ears and larynx were normal Sinuses transilluminated fairly well There were no nodes or masses in the neck

Laboratory tests revealed a trace of albumin in the urine which was otherwise normal Kahn negative w b c, 7050, hb, 85 per cent, 13 2 gms, hematocrit, 43 per cent Differential count was normal Chest X-ray revealed no abnormal findings Sinus X-rays showed a homogenous density in the left nasal cavity with some clouding of the left ethmoid cells There was no evidence of any bone destruction

On Sept 18, 1956, the left nasal cavity was explored by way of a left lateral rhinotomy The left maxillary sinus mucosa was normal but there was inward bulging of the medial sinus wall The tumor mass in the nose and the entire lateral nasal wall were resected with the turbinates

Pathology report well differentiated adenocarcinoma (cylindromatous type)

Study of the slides revealed perineural lymphatic invasion Follow up irradiation was considered advisable This was given in the form of external irradiation to two ports The total dose was 3000 r with the following factors 200 KV, 20 MA, filtration 1 2 mm cu, std 50 cm

Case 3 Mrs A W, a 60 year old housewife, had had inspiratory dyspnea and a dry cough for about two years Difficulty on inspiration became progressively worse, and was quite marked on exertion She stated that she coughed up some dark material mixed with the mucus She noted a progressive loss of weight from 225 lbs to 190 lbs, over a period of two years

Her general health otherwise had been good, with no serious illnesses over the years Physical examination revealed an obese woman in no acute distress with slight respiratory stridor on deep inspiration Ears, nose and throat appeared clear There was moderate lymphoid hyperplasia at the base of the tongue

Indirect laryngoscopy revealed normal vocal cords Just below the right true cord was a large smooth pale tumor mass projecting into the subglottic airway and partially obstructing it No nodes or masses were palpable in the neck On November 1 1956 direct laryngoscopy and biopsy were easily accomplished and the patient returned to her room

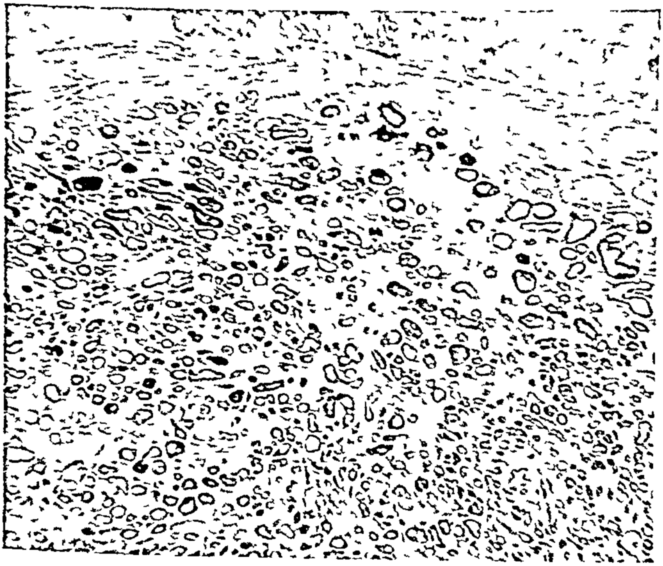

Fig 1 Low power view of cylindroma of tongue showing typical pattern (X30)

breathing easily Soon afterward, however, she developed more severe respiratory difficulty and tracheotomy was done giving immediate relief of all respiratory difficulty

The pathology report of the large sessile subglottic mass was adeno carcinoma cylindromatous type On Nov 12, 1956 total laryngectomy with wide resection of the tumor mass was done About a year later she noted some difficulty swallowing There was no evidence of tumor recurrence and complete relief was obtained by gentle dilatation with mercury filled bougies to 44 F There has been no further difficulty in swallowing to date

HISTOLOGY

The histologic diagnosis of the cylindroma depends upon recognition of a rather characteristic tissue pattern which has been reported throughout the literature It differs from many other new growths in that it does not have any typical cells of distinctive shape, size and staining quality which are diagnostic The pattern of the tumor (see Figs 1 and 2) reveals a glandular structure which appears to arise from the ducts of mucous glands The epithelium often shows a degenerative metaplasia of the cubical lining cells into small polygonal cells which have very little protoplasm [45] It often evidences a rather strikingly uniform histologic appearance consisting of intertwining masses or cylinders of parenchymal cells surrounding rounded spaces filled by hyaline or mucoid eosinophilic or basophilic material In many cylindromas there are gradations from the uniform and prominent fenestrated pattern (see Fig 3) into more solid elements, or other patterns similar to basal cell epithelioma of the skin This resemblance to certain basal cell skin tumors has been demonstrated by numerous investigators [31,57 58 59]

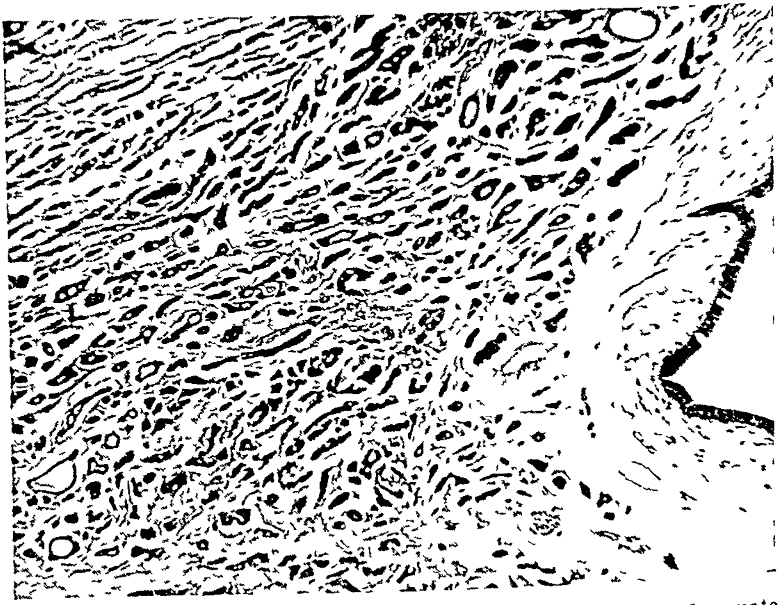

Fig 2 Cylindroma of the larynx Low power view of adenomatous pattern beneath intact mucosa (X30)

Both Ahlbom[17] and Ringertz[25] employ the term basalioma to describe these tumors In their studies there is both a solid and a cystic variety of basalioma, each having the histologic characteristics of cylindroma, described many years earlier by Krompecher[4] under the name "basallzellenkrebs"

The cylindroma (basalioma of Ringertz, adenoid cystic carcinoma of Foote and Frazell[44]) appears to develop from the ducts of the mucous glands This may be in the major salivary glands (submaxillary and sublingual have mucous components) or in the mucous glands widely distributed beneath the mucosa of the upper digestive passages (palate, tongue, lips mouth, pharynx) and the upper and lower respiratory passages[60] These glands and ducts are clearly demonstrated beneath the mucosa of the tongue, palate, nose and larynx in Fig 4 The large clear mucus-containing cells are surrounded by smaller more deeply staining cells Bauer and Fox[40] studied several cylindromas and concluded that these smaller deeply staining cells gave rise to the tumor These components are

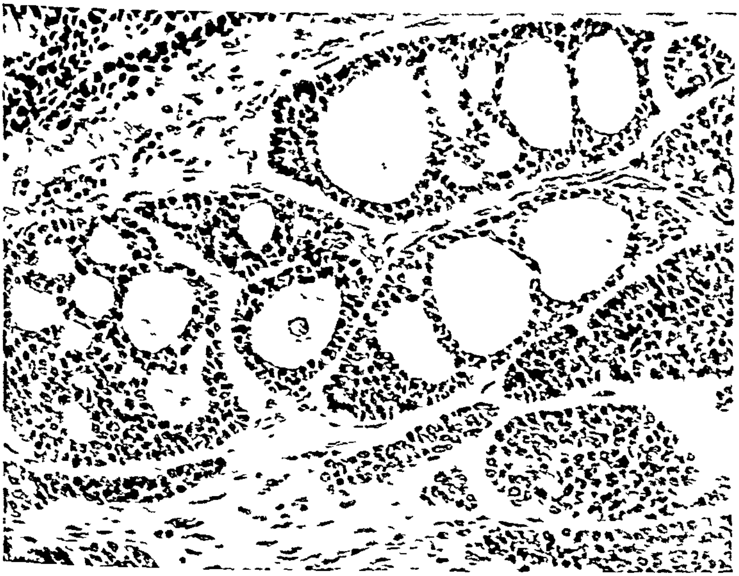

Fig 3 (X200) Lacy pattern of adenocystic variety of cylindroma (nasal cavity)

called "basket cells" and are considered contractile elements, or myoepithelial cells They described the masses of epithelial cells as basket cell masses and named the tumor "adenomyoepithelioma" In many microscopic sections showing both normal glands and early tumor development, there appears to be more clearcut evidence of development of this tumor from the duct cells (see Figs 5 and 6)

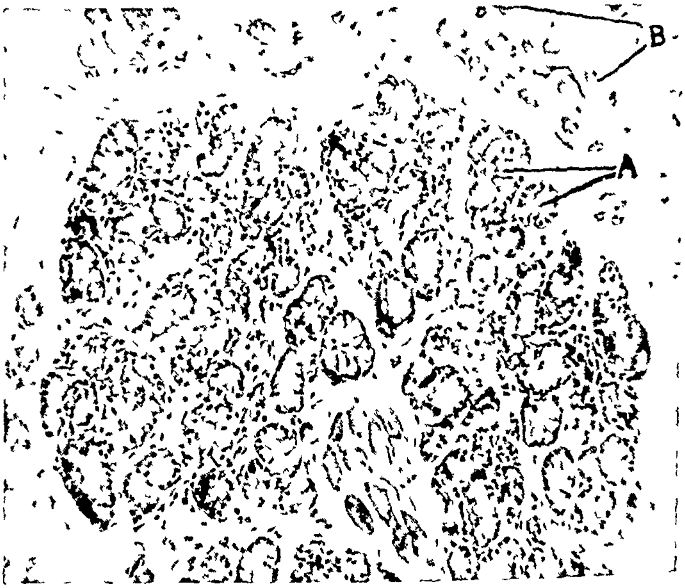

Fig 4 Mucous glands and muscle in the submucosa of the tongue A —Normal acini B —Muscle fibers (X100)

Cylindromas may resemble mixed tumors, but usually they are found to be relatively circumscribed, about 2 to 4 cm in diameter and reveal little tendency to encapsulation The capsule, when present, is usually incomplete, probably accounting for the dangerous clinical character of the tumor, namely, its tendency to persistent infiltration The mass is usually relatively firm, yellowish, or grayish white, having a homogenous appearance with relatively little tendency toward cystic degeneration or hemorrhage

Cylindromas of the trachea and bronchi usually possess a characteristic appearance Inasmuch as they develop beneath the mucosa, presenting themselves as a smooth rounded mass projecting into the lumen of the bronchus, they are often covered by intact bronchial epithelium Their microscopic appearance is almost identical with that of cylindromas elsewhere They may extend beyond the wall of the bronchus and are capable of infiltrating widely into the surrounding lung tissue

The histologic pattern of Case 1 (tongue) is demonstrated in Figs 1 and 6 There are numerous discrete duct-like tubules observed scattered through the partly destroyed and infiltrated tongue muscle Some of the smaller masses appear quite solid All are made up of small oval or cuboidal cells which stain deeply The microscopic picture of Case 2 (nasal passage, middle turbinate region) is shown in Fig 3 In this section there is more of the lacy, cystic pattern characteristic of an adenocystic carcinoma Here again the epithelial masses consist of small, uniform deeply staining cells with large nuclei and a scanty cytoplasm In some areas there are

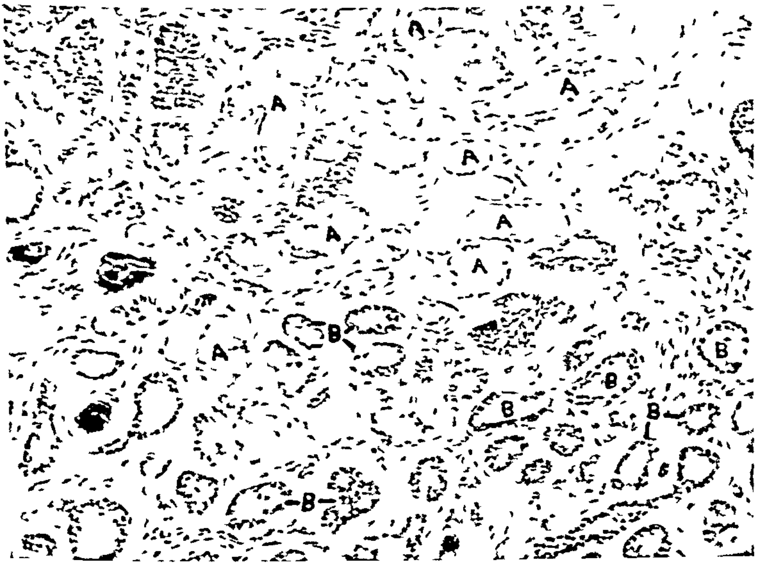

Fig 5 Tumor of tongue with normal mucous acini (pale) surrounded by deep-staining tumor acini and ducts A—Normal acini B—Tumor

large cell masses resembling basal cell carcinoma, sometimes described as a solid basalioma

Case 3 (larynx) also demonstrates the characteristic pattern of cylindroma with many infiltrating adenomatous masses of deep staining cuboidal cells scattered through the stroma *Portions of this tumor, however, evidence many small solid* masses of deep staining cells

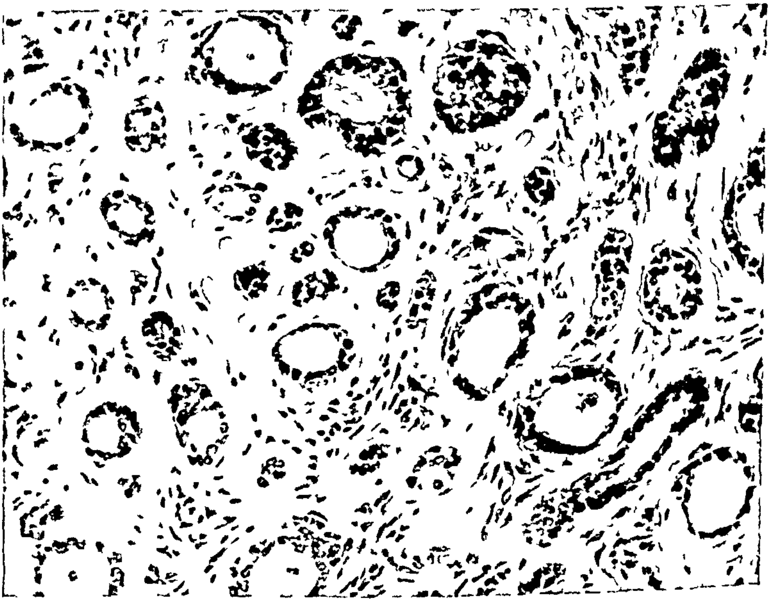

Fig 6 Cylindroma in higher power view demonstrates the appearance of duct origin (X200)

The sections from three cylindromas, those of the tongue, nasal cavity and larynx, respectively, reveal a variety of patterns, all of which have an adenomatous appearance and consist of typical cell masses of deep staining cuboidal cells with large nuclei and scanty cytoplasm Despite this variety of patterns, even within a single tumor mass, there is an overall uniformity of appearance readily recognizable as being characteristic of cylindroma Numerous reports in the literature contain excellent illustrations which demonstrate this typical appearance [2,25 32 37 38 44 45,56 57]

CLINICAL ASPECTS OF CYLINDROMA

Though the histologic picture of the cylindromas possesses a rather characteristic pattern, the clinical findings and course of these tumors do not. In a great measure these are dependent upon the site of origin of the tumor. It is generally agreed that these tumors originate from mucous glands which are scattered throughout the mucosa of the upper respiratory and digestive passages. The glands, with their ducts, may give rise to cylindromas beneath the mucosa of the lips,[61] oral cavity,[42] palate,[2, 65] pharynx,[5, 36, 43, 62] nose,[25, 32, 33] paranasal sinuses,[17, 25, 36, 43, 63] trachea,[36, 53, 54, 64] or bronchi.[36, 40, 51, 54, 55]

These tumors may occur also in the large salivary glands. These glands have large, mucus producing acini (see Fig. 4) and many deep staining ducts lined with cuboidal epithelium. In the large salivary glands, benign, so-called mixed tumors, are common, especially in the parotid gland,[66, 67, 68, 69] however, even in studies of large series of parotid gland tumors, a high percentage is found to be malignant, either adenocarcinoma or cylindroma. Quattlebaum, Dockerty and Mayo[41] found that 10 per cent of a series of consecutive primary parotid neoplasms appeared to be adenocarcinomas of the cylindroma type. This group of 21 patients had severe radiating pain and local fixation in over 40 per cent of cases, and facial nerve involvement was a commonplace experience. Surgically, the tumors were found to be more infiltrative than encapsulated. In this group there was an astounding recurrence rate of 75 per cent!

McDonald and Haven,[42] in a series of 339 cases, found 86 cylindromas. These produced symptoms referable to the site of origin and were characterized by slow growth, innocence of their gross appearance, and a marked tendency to recur following treatment. If cure is not accomplished, the tumor usually progresses slowly, attested to by the fact that 22 of the patients reported in this series lived an average of 7.4 years without cure.

The symptoms and findings reported by numerous authors are quite similar. Kramer and Som[36] found that the overlying mucosa was usually intact, although in some cases ulceration and breakdown has been reported, especially in lesions involving the oral cavity.[2] As was previously stated, the tumors are poorly encapsulated and tend to infiltrate surrounding tissues, losing mobility, and becoming fixed. They often are sessile masses with a wide base and a smoothly rounded surface.

Patients, in the series being reported here, demonstrated rather characteristic findings. The woman with a tumor of the tongue was not even aware of the presence of her tumor, which was found by her dentist during the course of a routine extraction. The mass itself was about 1.5 cm. in diameter covered by normal tongue epithelium with no bleeding or ulceration. Because of the paucity of symptoms produced in many instances, it is readily understood why these tumors can be present for a long period of time before they are noticed.

The second patient had a large intranasal cylindroma which produced the classical symptoms of carcinoma, unilateral obstruction and hemorrhage from the involved side of the nose. The mass itself was smooth, nonulcerated, filling the airway on the left side. It was readily recognized as a tumor on inspection of the nasal cavity and X-rays revealed no bone invasion or destruction. Sections of the tumor mass after surgical excision showed distinct perineural lymphatic invasion (see Fig. 7), considered to be one of the serious malignant features of this type of tumor.

The absence of a distinct capsule, the infiltrative tendencies and the invasion of adjacent perineural lymphatics lead to a high incidence of so-called recurrence of the disease, which may well be persistence of a slow growing tumor not completely eradicated.

Rawson, et al.,[61] in reviewing 160 cases of salivary gland tumors found 11 cylindromas. They grouped these with two other types of tumors as being of low-grade malignancy, malignant papillary cystadenoma and mucoepidermoid tumors. Despite this "low-grade" classification there was local recurrence in 91 per cent of the cylindromas.

Many other observers have reported a significant incidence of carcinoma in salivary gland tumors, a high percentage of these being cylindromas. In one series[32] of 241 parotid tumors, 17.4 per cent were reported malignant. In another series[33] of 81 primary submaxillary gland tumors, adenocarcinoma of the cylindroma type was found in 18.5 per cent of the cases. These patients often had a brief clinical history with pain and local fixation as prominent features. There were pronounced infiltration tendencies, with selective invasion of nerves. The rate of recurrence was high. Similarly, in another study of 212 cases of parotid tumors[34] the incidence of carcinoma was found to be at least 20 per cent.

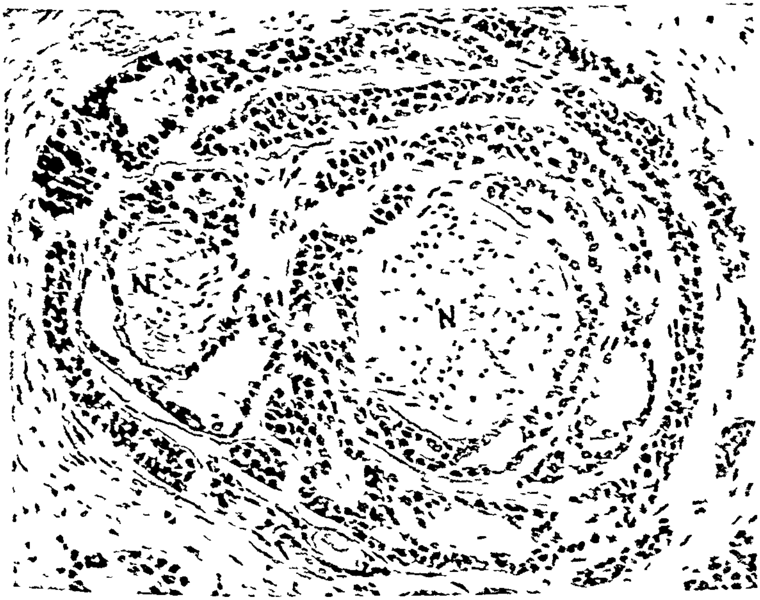

Fig. 7. Photomicrograph of cylindroma of nasal cavity showing perineural lymphatic invasion by masses of tumor cells. Deep-staining cells about the lighter nerve fiber (N) are the tumor cells.

Cylindromas occurring in the larynx, trachea and bronchi produce symptoms and findings characteristic of most tumors involving those anatomical sites. The third case reported in this series developed a tumor in the subglottic region beneath the right true vocal cord. Her symptoms were those which tion and breakdown has been reported, especially in lesions involving the oral cavity.[2] As was previously stated, the tumors are poorly encapsulated and tend to infiltrate surrounding tissues, losing mobility, and becoming fixed. They often are sessile masses with a wide base and a smoothly rounded surface.

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Many other observers have reported a significant incidence others[51, 53] reported bronchial adenoma with metastasis and the photomicrographic illustrations of these cases clearly reveal cylindroma. McDonald reviewed the histological findings in 27 cases of tracheal tumor, among them being eight cylindromas. The symptoms and findings included dyspnea, stridor, wheezing, atelectasis, emphysema, cough, and varying degrees of hemoptysis. X-ray studies often demonstrated a mass in the trachea with encroachment on the airway. Bronchoscopic examination revealed the site and extent of the tumor mass and permitted tissue to be removed for biopsy. In some patients treatment by bronchoscopic removal and fulguration was accomplished.

Reid[55] has urged that careful study of biopsy material should be carried out, because so-called bronchial adenomas reveal distinct histologic patterns, the one being cylindroma which, of course, has a much more serious prognostic significance. These should probably be treated surgically and considered as low grade malignant tumors.

We call attention to the fact that all three of the patients in the series being reported were women. Four were women in Pollock's series[43] of five cases. Others, likewise, have noted a preponderance of women having cylindromas. The majority of these tumors occur in adults, but one has been reported as having occurred in a child.[74]

METASTASIS

There is sufficient clinical and histologic evidence to indicate that cylindromas should be considered as malignant tumors. Ahlbom[17] classifies some of them as "semimalignant" but it is difficult to understand exactly what that means. Since they are of glandular origin, the term adenocarcinoma, cylindroma type, would be more accurate, descriptive, and inclusive. Many of these tumors show a more anaplastic and less differentiated microscopic picture. It seems reasonable, however, that the term cylindroma should be retained because it connotes a certain rather specific, although unusual histologic pattern. There are a large number of reports in the literature describing metastasis from these tumors.[2, 17, 25, 30, 31, 37] developed as a result of the progressive enlargement of a mass encroaching on the airway She noted increasing dyspnea with some stridor Examination revealed a large, smooth sessile obstructing mass in the larynx, immediately beneath the right vocal cord Biopsy revealed a cylindroma (see Figs 8-a and 8-b) Tumors in the trachea such as these have symptoms in common Bronchial tumors often bleed, and hemoptysis in young persons should give rise to suspicion of a bronchial tumor, possibly a cylindroma Creif and Bucher[50]

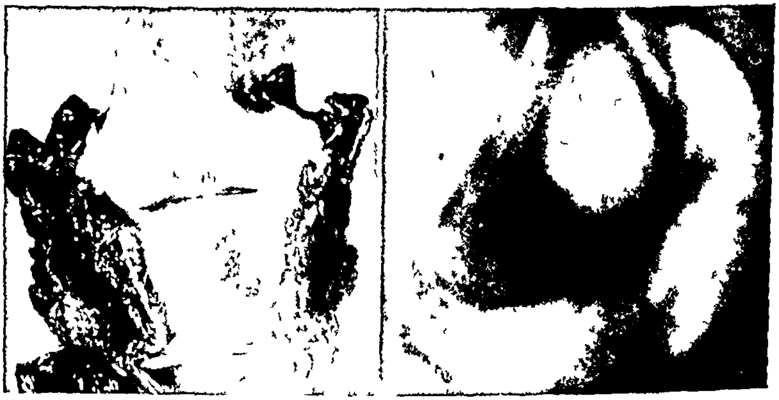

Fig 8-a Larynx, surgical specimen opened posteriorly revealing smooth tumor beneath the right true vocal cord b—Endoscopic view of cylindroma of the larynx

reported three histologic types of bronchial adenoma, one resembling cylindroma, however, in their series, the clinical course of all three cases was found to be about the same They did not consider it malignant and reported that these tumors did not metastasize, nor were they influenced by irradiation therapy

Adams, Steiner and Bloch[10] took an entirely different point of view in their report of five cases It was their opinion that it was impossible to determine if any polypoid bronchial tumor would remain continuously benign They felt that the extent of these tumors could not accurately be determined by X-ray or by the bronchoscope, and that there was no way clinically to determine development of metastasis Later, the surgical[25,26,27] method is the treatment of choice, and that all accessible tumors should have as wide an excision as possible. They express the thought that radiation therapy alone has little value in the ultimate cure of this type of tumor, particularly when they occur in the parotid and submaxillary glands.

Spies,[31] in 1930, reported that cylindromas were radiosensitive, and employed irradiation therapy as the primary means of treatment. Since that time Ahlbom,[17] Ringertz,[25] and Edvall[63] have been the outstanding proponents of a combined radiosurgical approach to these tumors. The latter (Edvall) reports the routine use of teleradium preoperatively (1 to 3 fields, giving 2000 to 3000 r to each), followed by surgical excision after the skin reaction subsides. Following surgery, radium tubes were applied to the wound cavity for three to four hours. Although most of the tumors reported treated under this regimen were parotid tumors, there was an overall recurrence rate of only 3.6 per cent and the rate for the malignant tumors was only 12.8 per cent.

The patients in the series being reported were treated by wide surgical excision of the tumor. The nasal tumor was exposed by lateral rhinotomy, and the mass in the region of the middle turbinate was excised, together with the entire lateral nasal wall. No evidence of ethmoid or maxillary sinus involvement was observed. There was perineural invasion revealed histologically, so that this patient was given postoperative irradiation. The patient with the large subglottic tumor mass was treated by total laryngectomy. Since there was no evidence of spread beyond the larynx, no irradiation was given.

The treatment of cylindroma in the trachea or bronchi poses additional problems. Wide excision of tracheal tumors usually cannot adequately be carried out, so that bronchoscopic removal, followed by fulguration of the base is the treatment of choice. In the bronchi these tumors should probably be treated by surgical excision. The cylindroma of the bronchus has a more serious prognosis than the benign adenoma, therefore, wide excision is the treatment which will probably be most effective.[48,49,45] Local treatment through a broncho-

[38,41,43,45,49,51,54,56] They can spread to the regional lymph nodes and later may evidence widespread general metastasis

Harrison[2] has reported an illustration of extensive, bilateral pulmonary metastasis from a recurrent cylindroma of the palate Russell[45] shows photomicrographs of two cases of distant metastasis, one from the oral cavity to the ilium, and the other from the tonsil region to the lungs In each instance the metastases reveal the typical pattern of cylindroma

The patients in this present series have thus far shown no evidence of metastatic spread after a period of observation of approximately two years A careful follow-up is maintained, knowing that the prognosis must be guarded since these tumors often demonstrate a slow growth with late development of metastases

Mulligan[38] reviewed 22 cases of metastases from "mixed" tumors of salivary glands The most common sites of metastatic spread were the lungs, pleurae and liver Less commonly involved were the bones, lymphatics, kidneys and spleen In eight of these cases the term cylindroma was applied to the tumor In eight others, adenocarcinoma, malignant glandular epithelioma, or cylindroma were considered It would appear that 16 of the 22 tumors surveyed having metastases were either cylindromas or cylindroma-like adenocarcinoma of the salivary glands

TREATMENT

Over the years the treatment of salivary gland tumors has included incision and curettage, enucleation, surgical excision, irradiation, and combinations of pre- and postoperative irradiation with surgical excision The most effective means of therapy for cylindroma in its variegated locations has not been clearly defined, although there is the current thought expressed that a combination of wide surgical excision and irradiation, before and after surgery, promises the best results

A review of the past literature and a study of the histologic features of the three cases in the series being reported, clearly indicate that cylindromas are malignant tumors and should be treated as such Some observers emphatically state that

The series reported here demonstrates the classic histologic pattern of cylindroma (see Figs 1, 2, and 3) It indicates the varied sites at which such tumors may be found, and clearly evidences the origin of such tumors from the mucous glands This series, though relatively small, reveals the characteristic development of this specific type of tumor It has been found over the years that these poorly encapsulated tumors tend to grow slowly and progressively infiltrate the surrounding tissues This occurs not only in the major salivary glands, but also in the buccal cavity, tongue, larynx or bronchi They tend to recur after excision, and their rate of recurrence is exceedingly high, so that the prognosis must be guarded They evidence a characteristic perineural lymphatic invasion This series demonstrates the classic picture of perineural lymphatic invasion, one of the outstanding clinical features of this group of tumors

Cylindromas of the upper digestive and respiratory passages are best treated by wide surgical excision Many observers in recent years have recommended surgical excision combined with radiation therapy, to assure the best results, although some clinicians still consider that these tumors are radioresistant and advise radical surgical management Many of these tumors occur in the parotid gland where the presence of the facial nerve in adjacent tissues makes surgery more difficult Despite this, surgical treatment is the best means of managing these tumors Janes[75] strongly supports this view in the management of parotid tumors and states, "No case in which an adequate removal seems possible, even though the whole facial nerve must be sacrificed, should be treated by radiation alone"

The recurrence rate of cylindromas is so high and the disease so relentless in its course that treatment must be instituted early and adequately if a cure is to be effected Three cases of cylindroma have been reported in some detail in an attempt to increase the body of evidence which has been gathered in the literature about these tumors These patients have all been treated with wide surgical excision The tumor of the tongue showed no evidence of extension beyond that organ and was excised with a wide margin of normal tissue.

scope is usually less satisfactory since it often cannot clear up the distal lung suppuration nor remove tumor beyond the wall of the bronchus Severe hemorrhage is another complication which demands an external surgical approach

DISCUSSION

The question of the histogenesis of salivary gland tumors of the cylindroma type has not been settled to the complete satisfaction of all investigators,[80] however, it can be stated that at the present time a sufficient body of evidence has been collected in the world literature to give much weight to the theory which favors the origin of such tumors from mucous glands and their ducts in the respiratory and upper digestive passages It is possible that in the future, with the development of new techniques such as tissue culture or microstaining studies, additional information regarding histogenesis may be forthcoming

In recent years, Hempleman and Womack[78] have conducted studies on mixed tumors to determine the origin of the myxomatous and cartilaginous areas by means of microchemical methods These tests would indicate that the "cartilage" in these tumors is of mesenchymal origin, and the stromal changes in this epithelial tumor may be caused by so-called "organizer" substances in the tumorous epithelium

Favata[79] compared tissue cultures of parotid tumors with cultures of duct cells from fetal parotid glands and found that both developed in essentially the same pattern His study suggested that the pleomorphism that characterizes these tumors may result from secondary changes in a neoplasm composed almost exclusively of epithelium

The cylindromas are a large and rather distinct group of new growths with a rather characteristic microscopic tissue pattern, recognizable in growths from areas as distinct anatomically as the nasal passages, tongue or bronchi This characteristic pattern, probably best described as an adenocarcinoma, cylindroma type, has now been correlated in many reported cases with both the clinical findings and results of treatment

Three additional cases of adenocarcinoma, cylindroma type, are reported, including clinical findings, microscopic study and modes of therapy

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Such tumors in the buccal cavity are usually accessible to surgical treatment and can be excised The tumor of the larynx was a large one immediately below the vocal cord Wide excision of such a relentless growth was accomplished by total laryngectomy, encompassing the entire tumor and a margin about it

These tumors occurring in the nasal cavity, paranasal sinuses or maxilla adjacent to the maxillary sinus should be treated by wide exposure through an external approach to the nose and resection of the tumor including the maxilla, if that, too, is involved In this series the cylindroma was located high in the nasal cavity Wide excision was accomplished through a Fergusson incision, combined with external irradiation therapy, because of the presence of perineural lymphatic invasion

SUMMARY AND CONCLUSIONS

Cylindromas appear to arise in mucous glands and their ducts and occur wherever these glands are found in the upper digestive and respiratory passages

Their histologic pattern demonstrates some variability, but photomicrographs have been presented to demonstrate a rather typical pattern recognizable in tumors from many different anatomical sites

These tumors, poorly encapsulated, infiltrate widely and have been shown to metastasize not only to regional nodes but also to distant sites

Treatment must be instituted early and adequately Wide surgical excision is the treatment of choice, although many feel that combined radiosurgical therapy is more effective Surgically inaccessible tumors should be treated by irradiation

The term cylindroma seems to be so descriptive of the typical pattern of the tumor that many have urged its general acceptance Nevertheless, cylindromas are malignant tumors and the word "cylindroma" alone does not clearly reveal this Since these tumors are of glandular origin, the term adenocarcinoma, cylindroma type, describes them more completely

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AN UNUSUAL CASE OF ETHMOIDAL MUCOCELE

Surgical Management and Ten-Year Follow-up[*]

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The case presented here is significant because of its etiology, clinical course, surgical correction, and especially because of its extended and closely evaluated postoperative period.

A mucocele is basically a retention of mucoid secretions within a paranasal sinus that may result in erosion of its bony confines. There is some disagreement as to exactly what structural components are necessary for a diagnosis of mucocele. The following classification has been offered.[1]

1. *Primary Mucocele.* This type is considered to be a "true mucocele" and consists basically of a thin-walled sacular swelling. The membranous capsule consists chiefly of goblet cells. Its retained mucinous secretions are thin and lemon yellow in color. There is a notable lack of inflammatory responses. Such a cystic structure may have erosive potential and probably has its origin from an occluded goblet cell.

2. *Secondary Mucocele.* This type is characterized by a relatively thick wall of sinus mucosa. There is preservation of the lining epithelium, but no particular predominance of glandular elements. Evidence of chronic inflammation is usually present. The contained fluid, probably an exudate, may vary widely in character from serous to a thick greenish sludge with cholesterin crystals. When purulent exudate predominates, the structure is often referred to as a pyocele. Such secondary mucoceles are more frequently encountered than the "true" type and probably have their inception in

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periostial line becomes indistinct while the sinus wall assumes a smooth outline with a loss of septa and scalloping Bony erosion of a sinus wall may at times be apparent On occasions the erosion may be so marked that a true malignant tumor may be suspected from the roentgenogram[9]

CASE REPORT

Present History The patient, a 30 year old white male, was admitted to the E N T service on Feb 11, 1949, complaining of continuous headaches for the past three weeks The headaches were described as severe and incapacitating The "bursting" type pain was localized over the central portion of the forehead The patient states that at the age of eight years he was kicked in the face by a horse, which resulted in a gross nasal and facial deformity He describes periodic headaches in his childhood, and a partial loss of vision in the left eye since the accident At times he has a clear, watery to-thick mucoid nasal discharge that seems to bear no relationship to his headaches Since 1943 his headaches have become much more severe, and for the past few years he has been taking as many as 20 aspirin tablets a day for relief He states that because of his continued pain he has become very irritable and cannot concentrate on any type of work He has not held regular employment since his army discharge, but has worked as a day laborer at odd intervals He alleges to have frequent clashes with his wife and children due to sudden emotional outbursts and inability to control his feelings Approximately two years ago he began to drink alcohol to excess in order to relieve his pain and nervousness

Past History The following portion of the past history was verified by official military sources and from the records of previous hospitalizations The patient served in the armed forces from Nov 30, 1942, until June 19, 1943 During this period he was seen in the dispensary on numerous occasions because of headache He was eventually hospitalized and given a neuropsychiatric discharge Following his discharge from the service he was not hospitalized again until February, 1948, at which time he was treated for pneumococcal meningitis He apparently recovered completely after antibiotic therapy and was released His next hospitalization was not until Nov 12, 1948, at which time he was admitted to a neuropsychiatric service for evaluation for insulin shock therapy, however, while in the hospital he developed a thick mucoid nasal discharge, nuchal rigidity and fever No organisms were cultured from the spinal fluid, but the cell count revealed an increase in polymorphonuclear leukocytes The hospital record stated that no evidence of cerebro spinal fluid rhinorrhea was found He was again treated with antibiotics and released

Physical Examination Examination at the time of this admission to otolaryngology revealed a well developed well nourished individual in no acute distress, but complaining of localized frontal headaches (see Fig 1) Temperature 98 6° blood pressure 140/75, pulse 80 and regular E N T examination revealed the nose grossly deformed by a saddle-type deformity with a scarred and distorted nasal lobule There was crusted exudate in both nares The mucosa of the posterior nasopharynx was moderately hyperemic as visualized by nasopharyngoscopy Complete anosmia was noted A gross hemianopsia was present in the nasal field of the left eye The remainder of the examination was noncontributory

Ophthalmological consultation confirmed the hemianopsia which was the complete occlusion of the natural drainage system of the sinus involved

Mucoceles are not rare but can be considered uncommon The age incidence varies widely, but the average is around 40 years The sex appears to bear little relationship The frontal sinus is the most usual site with the ethmoid labyrinth next in frequency The sphenoid and maxillary sinuses are rarely affected [2]

The pathophysiological mechanisms necessary for the development of a mucocele are disputed, but most authors agree that inflammation and occlusion of drainage are prime factors [3,4,5,6,7]

Occlusion and infection may occur during the course of a variety of common problems, such as a severely deviated nasal septum, nasosinal allergy, nasal polyposis, or possibly benign tumefactions Trauma to the face and head with resulting fracture of the sinuses may be the antecedent cause Previous surgery to the frontal and ethmoid sinuses may at times be a factor Weille, in a review of 276 external frontal sinus operations, found a total of 16 postoperative mucoceles Thirteen of these followed a Jansen-Lynch or Killian type procedure, while only three were subsequent to obliteration of the sinuses [8]

The danger in a mucocele lies in its rather marked tendency for slow incipient expansion into neighboring cavities of the skull The signs and symptoms produced by such a growth are related to its expansion into or pressure upon adjacent structures It may erode into another sinus cavity, into the nasal cavity, into the cranial cavity, or into the orbit Because of the relative frequency of frontal sinus mucocele, and with its predilection for involving the orbit, the ophthalmologist is often the first physician to encounter the patient with such a growth

The diagnosis is suspected when any cystic type mass involving a paranasal sinus can be demonstrated A roentgenographic examination of the area involved is usually highly informative The involved sinus characteristically appears expanded with a decrease in its density The usual mucoperiostial line becomes indistinct while the sinus wall assumes a smooth outline with a loss of septa and scalloping Bony erosion of a sinus wall may at times be apparent On occasions the erosion may be so marked that a true malignant tumor may be suspected from the roentgenogram[3]

CASE REPORT

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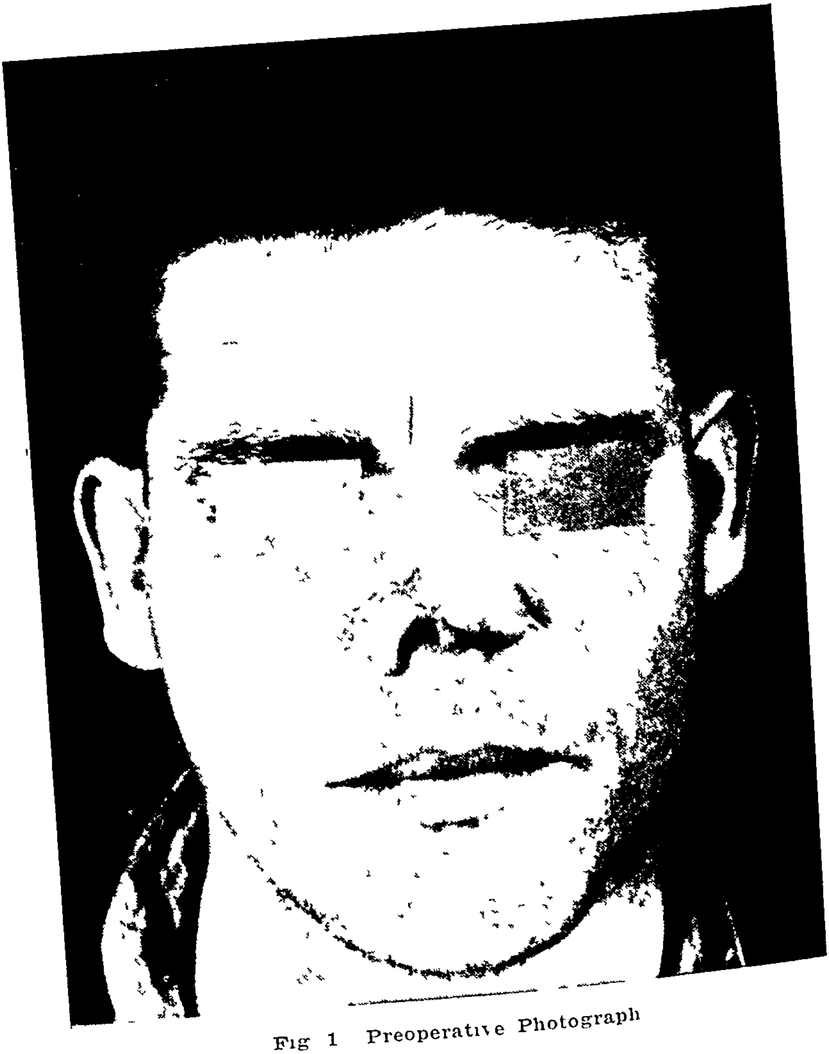

Fig 1 Preoperative Photograph

secondary to optic atrophy and probably resulted from a fracture through the optic foramen sustained at the time of his childhood injury

Laboratory and X-ray Laboratory data, including spinal fluid examination were within normal limits A chest X-ray revealed no evidence of pathology Sinus X-rays revealed clouding and thickening of the mucoperiostial lining of the left maxillary sinus, the right maxillary sinus was clear The frontal sinuses were small and shallow The sphenoid sinuses were clear There was a large cystic area in the mid line between the orbits in the region of the ethmoid sinuses (see Fig 2) Special views of the floor of the anterior cranial fossa demonstrated an absence of bone in the cribriform plate

Course in the Hospital After the work up was completed it was felt

Fig 2 Preoperative Waters view of paranasal sinuses showing large cystic appearing area in the region of the ethmoid sinuses

that the patient had a large mucocele in the region of the ethmoid sinuses The following operation was performed on Feb 10 1949

Under general endotracheal anesthesia an eyebrow incision for exposure of the frontal and ethmoid sinuses was made on the right After the soft tissue and periosteum were elevated near the medial canthus a thick wall cyst dark green in color was encountered There was marked erosion of the orbital wall of the anterior ethmoid cells and of the nasal bones The latter terminating inferiorly in a feathered edge at their midportion A similar incision was then made on the left side and joined across the root of the nose The nasal bone and orbital wall of the anterior ethmoids were similarly involved on this side The cyst

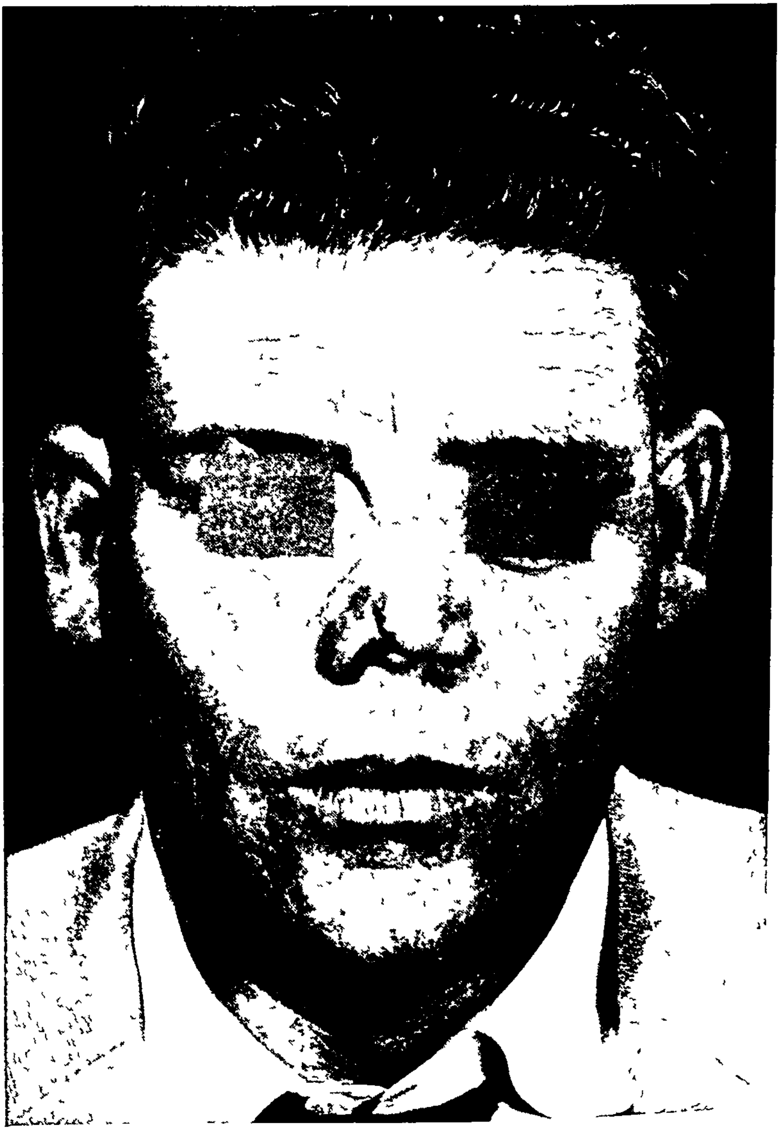

Fig 3 Photograph of patient ten years postoperatively

had completely replaced the entire ethmoid labyrinth bilaterally and in addition had eroded into the lower third of the frontal sinuses, bilaterally destroying the floors and any recognizable ducts The frontal sinuses were filled with thick, dark green secretions while the mucosa was indurated and polypoid in nature After the sac was dissected laterally and posteriorly, it was necessary to open it to facilitate removal The sac contents consisted of a dark greenish viscous fluid, in which numerous cholesterin crystals were noted After the sac was dissected inferiorly the remaining cavity communicated through a wide aperature with each side of the nasal vault Superiorly, the dehiscence in the floor of the anterior cranial fossa could be palpated in the midline and measured approximately 1½x3 cm No cribriform plate could be identified All of the cyst was then removed except for its superior aspect, where it was left *in situ* as a covering for the dura mater in the floor of the anterior cranial fossa Next a bilateral radical obliterative frontal sinus procedure was performed Several layers of gelatin foam were placed over the defect in the floor of the skull Iodoform gauze was then utilized as intranasal packing The incision was closed and a pressure dressing applied There was a brisk hemorrhage during the procedure and the patient received 1,000 cc of blood while on the table There were no surgical complications

Fig 4 X-ray of paranasal sinuses ten years postoperatively showing residual defect in ethmoid area

Immediate Postoperative Period The patient maintained a temperature of 100° to 101° for the first three days postoperatively and then became afebrile and remained so The sutures were removed on the fifth postoperative day The nasal packing was gradually removed and was completely out by the tenth postoperative day The patient was maintained on antibiotics for three weeks The pathologic report on the surgical specimen was compatible with a mucocele (secondary type) Examination by the third week postoperatively revealed a slight flattening of the forehead The external wound was completely healed Nasopharyngoscopy showed the area previously occupied by the mucocele to be apparent now as a concavity The roof of the nasal vault appeared to be partially lined by granulation tissue and partially by ingrowing mucosa The patient's headaches gradually subsided and he was discharged one month after surgery

Follow-up Course This patient has been followed at intervals for a period of ten years The last examination prior to this report was February, 1959 At this time the patient presented a pleasant, pleasing, cooperative personality He is free from headache, except for an occasional "tension headache" in the back of his neck which he experiences after an unduly tiring day working in his drugstore, which he owns He is free of nasal discharge or discomfort except when he has an upper respiratory infection which he experiences infrequently His anosmia has persisted He has had no more symptoms of meningitis or sinusitis His alcohol consumption is no longer a problem, and he states that he and his family now enjoy a wholesome relationship Examination on the last visit revealed the previously described nasal deformity and minimal forehead deformity The mucous membranes of the nose appeared healthy Nasopharyngoscopy revealed a definite concavity occupying the region of the cribriform plate This area appeared to be lined by normal healthy mucous secreting membranes, and no granulation tissue was in evidence Transmitted pulsation of the overlying cerebral cortex was noted (see Figs 3, 4)

COMMENTS AND CONCLUSIONS

The antecedent cause of this patient's mucocele would seem to be his facial trauma in early life Although his complaints of headaches had apparently existed from that time, it was some 23 years later before the cause of such headaches was determined

In this age of rapidly increasing facial trauma, fractures of the sinus cavities are naturally increasing proportionately The primary emphasis in the management of sinus trauma is the prevention of infection and its sequela, and the restoration of function and cosmesis It would also appear advisable to give more consideration to the probable but often long delayed pathology which may result from such trauma As experience mounts and long term observations increase, it may indicate that more vigorous initial therapy will be necessary in such injuries This is especially true if there is a history of previous sinus infection or upper respiratory allergy

This patient also had at least two episodes (and probably more) of bacterial meningitis, probably resulting from the destruction of the usual naso-cranial barriers The association of intracranial infection and recent previous or co-existent head trauma is not infrequent, however, the coincidence of acute meningitis with chronic disease elsewhere in the skull is generally neglected Such correlation, however, is a fundamental precept in the management of chronic suppurative states about the cranial cavity, the time honored province of the otolaryngologist It should be our responsibility to disseminate such a concept more widely

This individual's personality stamp of psychoneurosis seems to have played a substantial influence in his delayed diagnosis Any patient who bears such a stigma should be critically examined Functional disorders are so frequent in all aspects of modern medicine that one may become exceedingly complacent about making such a diagnosis It would appear that symptoms involving the head and neck structures are more readily ascribed to a functional basis than are complaints pertaining to other areas of the body where physical examination is less demanding

The surgical correction of a mucocele involving the fronto-ethmoidal area is at times difficult In this instance no attempt was made to remove the mucocele *in toto* The superior wall of mucocele was left intact as a covering for exposed dura of the anterior fossa To dissect this portion of the wall from the dura might have resulted in a dural tear, cerebrospinal fluid rhinorrhea or possibly postoperative intracranial infection If the sac had been removed in this area it may also have required the application of some substance such as fascia or skin graft, as covering for the dura By leaving the sac lining composed of sinus mucosa, functioning mucous membrane apparently has resulted Marsupialization of the sac seems to have allowed recovery of the mucosa to a functional state, and at the same instance provided an adequate covering of the bony dehiscence

In the case presented here the mucocele had eroded into three adjoining cavities the nasal, the cranial, and the frontal sinuses, the latter being extensively diseased Because of these operative findings, the incapacitating symptoms and the protracted clinical course, the obliterative type of frontal procedure was clearly mandatory The postoperative deformity was minimal, and the patient did not desire plastic correction of his brow or of his pre-existing nasal deformity

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TREATMENT OF LARYNGEAL PAPILLOMATOSIS WITH BOVINE WART VACCINE REPORT OF CASES[*]

O P MOFFITT, JR M D ,

Wichita Falls, Tex

Wart vaccine of bovine origin is commonly employed in veterinary medicine for treatment of papillomata of the oropharyngeal membranes of domestic animals and pets This has been prepared by extraction and formalin treatment of warty masses from healthy young calves[1] More recently, a bovine vaccine of embryonated chick embryo origin is available Rather uniformly good results are anticipated, particularly in the treatment of cattle and dogs Occasionally, autogenous vaccines have been effective after failure of commercially prepared vaccines

A young female child with rapidly growing papillomata presented a dangerous clinical course in spite of tracheotomy and repeated avulsions of the diseased tissue The effect of bovine vaccine was tested A rather dramatic cessation of regrowth occurred This, and three subsequent cases in which the use of vaccine may have had some influence on the course of the disease, are presented

Prior to its use, the bovine wart vaccine was further processed by passing it through suitable filters and culturing for contamination A course of injections was then given to a volunteer, who represented an adult recurrence of laryngeal papillomata[†]

REPORT OF CASES

Case 1 S N was first seen in July, 1955, at the age of two years She had been treated for hoarseness of six to eight weeks' duration, with various antibiotics A direct laryngoscopy at this time revealed a rounded

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[*] From the Department of Otolaryngology Wichita Falls Clinic-Hospital

[†] Carl Prichard Wichita Falls Tex prepared this vaccine from veterinary stock and took a series of injections No beneficial results were apparent nor was there any indication of ill-reaction in his case

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nodular mass which was removed from the area of the anterior commissure The pathologic diagnosis was papillomata On her release from the hospital, she was placed on a course of tetracycline drugs, which were continued through the next six weeks

During the remainder of 1955, she was hospitalized on three different occasions for gradually increasing hoarseness and wheezing respiration on exertion In each case, papillomatous masses were avulsed from the larynx Tetracyclines were given for four to six weeks, and on two occasions podophyllum was applied locally to the larynx

In January, 1956, she developed an episode of tonsillitis and fever with increasing respiratory obstruction which required a tracheotomy Subsequent direct laryngoscopy showed a marked extension of papillomatous material, with obstruction of at least two thirds of the glottic lumen, this was avulsed *An applicator of cotton soaked in radioactive phosphorus for the purpose of providing localized Beta radiation was prepared* A surface dose of irradiation was given following avulsion of the papillomata * She was released from the hospital with the tracheotomy tube still in place

Within three months' time there was sufficient regrowth of papillomatous material to occlude the larynx Difficulty with respiration was noted at any time mucus obstructed the tracheotomy tube During the latter part of April and early May, 1956, she was given Premarin under supervision of the endocrinologist This, however, was abandoned after approximately two weeks on further consideration of systemic effects

Some regrowth was evident on examination during June and again in September, 1956 On these two occasions it was necessary to remove a moderate amount of polypoid material from the larynx, because she was relying entirely on the tracheotomy tube for respiration

Removal of the papillomatous masses became necessary again on December 5, 1956 Following this treatment a course of bovine wart vaccine was begun Doses of 1 cc, 3 cc, 5 cc, and 5 cc again were given at three day intervals through December 26

In February, 1957, it became evident that her voice, instead of diminishing in volume and clarity during the next two or three weeks, had gradually improved By mirror examination it was thought that the cords were clear

In March 1957, direct laryngoscopy was again carried out and showed the larynx to be free of papillomata She was given an additional 1 cc dose of bovine wart vaccine at this time

During April and May, 1957 she appeared to have some difficulty intermittently with respiration and an occasional squeaky voice during upper respiratory infections On July 9, 1957, no papillomata were seen on direct laryngoscopy The glottic chink appeared adequate, although there was some suggestion of webbing of the anterior commissure The tracheotomy tube was removed

Subsequent examinations through the remainder of the year suggested a clear larynx During the summer months, however, it became evident that there was a well defined webbing of the anterior commissure This was treated by incision of the web and retention of an acrylic plate between the vocal cords, for a five week period of healing This was removed during July, 1958, and the voice was excellent for two or three months, when a sudden episode of hoarseness developed On laryngoscopy and re-examination at this time a small inflammatory granuloma was removed from the site of the previous acrylic implant Following this the voice remained satisfactory and airway good for the remainder of the year

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*The applicator was prepared by Dr Joe D Steed, surface radiation was measured directly and dosage time of application computed

Case 2 M O was first hospitalized at the age of two and a-half years on Dec 6 1955 He was seen in the hospital emergency room after an apparent "asthma" of six weeks' duration, which became progressively worse A tracheotomy was required as an emergency procedure Two weeks later direct laryngoscopy was carried out, and a large papillomatous mass was observed to fill the anterior half of the glottic chink with extensions posteriorly on the right side, these masses were avulsed Papilloma of the larynx was diagnosed microscopically After a few days of observation the tracheotomy tube was removed and he was released from the hospital with a good voice and respiratory exchange Tetracycline drugs were given during hospitalization with instructions to continue these for approximately six weeks after release from the hospital

Three months later he was doing well and had very little change in his voice

Six and a half months later he developed some hoarseness, for which he was hospitalized and re-examined by direct laryngoscopy (June 18 1956) A small amount of papillomatous material was avulsed and podophyllum was applied to the larynx He was again instructed to use tetracycline orally for four to six weeks

He did not return for four months (November, 1956), at which time he had developed an upper respiratory infection and had some difficulty in breathing After antibiotic drugs for several days, direct laryngoscopy was carried out again tracheotomy became necessary during the procedure Recurrent papillomata were seen and removed He was released from the hospital with the tracheotomy tube in plac on Dec 7, 1956, approximately one year after his first hospitalization Oral tetracycline drugs were again employed Later in the month indirect laryngoscopy suggested a slight recurrence of papillomata

During February some hoarseness was again evident, during which time satisfactory mirror visualization of the larynx was not obtained Bovine wart vaccine was given with a test dose on Feb 22 and 5 cc on March 1

He was hospitalized on March 8 1957 with the tracheotomy tube still in place On laryngoscopic examination a well-defined pad of papilloma was noted attached to the area of the posterior commissure with smaller paddings along the ventricular band Cupped forceps were again employed to avulse all visible tumor tissue in the larynx Following his release from the hospital, he did not return for continuation of the bovine papilloma vaccine

Hospitalization was arranged again June 12 1957, at which time he was wearing the tracheotomy tube satisfactorily, and was able to wear a plug in the tracheotomy tube indefinitely A well developed regrowth of papillomatous masses was noted and was removed Several days of tetracycline medication were given during hospitalization and apparently used for a few days after leaving the hospital

During July and early August he was returned to the office and, on these occasions did receive a definitive amount of vaccine Doses of 1 cc at weekly intervals were given for four weeks followed by a final dose on Aug 16, of 1 5 cc of the vaccine

Hospitalization was again arranged on Sept 24 1957 At this time a very small amount of papillomatous tissue was noted on both sides of the anterior commissure These were removed and an additional dose of vaccine was given while in the hospital

Following this, he was talking quite well, and examination by direct laryngoscopy was arranged for Dec 30, 1957 On this occasion the larynx was clear and the tracheotomy tube was removed

On March 15, 1958, approximately five months after his last dose of vaccine, he was hospitalized for repair of tracheal fistula The larynx was examined at this time without indication of recurrence of papillomata

Case 3 D M, a three year old white female, was first seen on July 18, 1958, for hoarseness since the preceding February, followed by loss of voice She had been seen elsewhere and was advised that there was a "growth inside the voice box," for which laryngoscopy was recommended

She was hospitalized and direct laryngoscopy carried out Anesthesia could not be used because of obvious retraction of the chest on any excitement or effort On exposure of the larynx with the direct laryngoscope, the anterior one half of the glottic chink was filled with an irregular nodular mass A large portion appeared to be pedicled from the anterior commissure This central mass was grasped with forceps, and a sufficiently large mass of tissue was removed for restoration of the airway Microscopic study subsequently reported benign squamous papilloma

Following intradermal tests on the same day, bovine wart vaccine, 0 3 cc was given Two days later an additional 0 6 cc was given She was released from the hospital with excellent restoration of the airway, and a hoarse voice Two additional doses of bovine wart vaccine in 1 cc injections were given during subsequent weekly intervals

She was hospitalized again after a 28 day interval At this time the voice was still husky On direct examination there was a marked diminution in the amount of papilloma present A 3 or 4 mm mass was noted in the anterior commissure and another similar sized mass in the mid cordal area on one side Following avulsion of these masses, the voice was of fair quality An additional 1 cc of bovine wart vaccine was given

She was seen again after an interval of three months She had done *very well except that the voice was intermittently somewhat* hoarse At this time, examination of the larynx showed rounding effect in the anterior commissure somewhat suggestive of webbing A biopsy taken from this area reported no papillomata

Tetracycline drugs were employed for four to five days, only at the time of hospital admissions

Case 4 M Z was first seen on July 15, 1958, at the age of 14 years, with a complaint of persistent hoarseness Papilloma of the larynx had been discovered at the age of six, during the course of clinical investigation of the cause for convulsions in his sleep He had had an abnormal voice from the time he learned to speak Papillomatous masses were removed from the larynx at this time, and he did fairly well for the next five or six years During the last two years, however, he had had laryngoscopy and removal of recurrent papillomata on three occasions The last procedure had not improved his voice An abnormal voice was impairing his school activities psychologically, and at the same time he had excessive dread of further laryngeal procedures

On examination of the larynx there was a well defined pad of papillomatous material in the anterior commissure, and a small mass on one arytenoid and the opposite ventricular band

Initial medical treatment consisted of aureomycin, which was continued for 30 days At the same time he was given estrogens for inhalation by nebulizer Around the first of September, 1958, the estrogen was discontinued and a mixture of corticosteroids with antibiotic substituted

During medical therapy no change was noted in the appearance of the larynx

On Sept 26 direct laryngoscopy was carried out, and the mass in the anterior commissure and extending along the anterior cord was removed To permit observation a small patch of papilloma situated on the top of the ventricular band was not disturbed Bovine wart vaccine injections were started the doses being given at weekly intervals starting with 1 cc then 1.5 cc and finally 2 cc

Postoperatively, the voice was definitely improved but lacked good quality During the succeeding month however his voice continued to improve Re-examination on Oct. 11, 1958, showed a very slight webbing in the anterior commissure and the area of papilloma which had not been excised had disappeared spontaneously

ADDENDUM TO CASE HISTORIES

Case 3 D M, showed reccrrence of papillomata on re-examination April 14 1959 A course of chick embryo wart vaccine and tetracycline drugs during the next two months was negative without effect An autogenous vaccine is being attempted by Dr E W Irvine, Jr Wichita Falls, Tex.

Dr W P Anthony, Fort Worth Tex reports the use of bovine vaccine in two cases with considerable regression in one instance, and no effect in the second

COMMENT

With the exception of Case 3, prolonged courses of wide spectrum antibiotics were employed For this case, use of antibiotics was deliberately limited to a few days postoperatively or during the course of acute infections

In 1950, Holinger and his associates[2] reported on the use of aureomycin therapy in heavy doses and prolonged administration for control of recurrences of papilloma of the larynx He reported seven cases which had shown regression in the growth In 1951,[3] he reported two additional cases and noted that a clear larynx had been obtained in three cases treated in the first group, and there was a regression in the growths of the remaining four.

Shortly after the publication of Holinger's first paper, I had occasion to treat a two-and-a-half-year-old white male by this method with success

Capps[4] surveyed treatment of papilloma of the larynx by circulating a questionnaire to a number of colleagues He concluded that no presently accepted therapy will control this disease. The various treatments advocated are listed He notes the frequency with which stenosis of the larynx results from violation of the anterior commissure surgically Webbing of the anterior commissure became a definite problem in Case 1

Webb[5] reported five cases of papilloma of the larynx which were treated with antibiotics, and, in particular, aureomycin Profiles of 15 additional unpublished cases treated at the State University of Iowa Hospitals were given He concluded "that massive and long-continued antibiotic therapy, with aureomycin in particular, effectively supplements surgery in the treatment of laryngeal papilloma"

In two of the reported cases, podophyllum applications to the larynx were made without evident influence upon the course of the disease Hollingsworth and his associates[6] reported successful treatment of five children with podophyllum applied locally to the laryngeal masses In previous personal experience with two adult recurrences of papillomata, one case appeared to be markedly benefited by repeated topical application of podophyllum, while another case was uninfluenced by this method of treatment

Successful topical hormone therapy was reported by Broyles[7] Amniotin in oil was applied by spraying a solution directly into the larynx with resultant clearing of papillomata Five cases were presented in the five to seven-year-old age group More recently, Szpunar[8] reported treatment by the injection of 1 to 5 mls of Stilbestrol into one or the other side of the larynx at a time

Silverblatt[9] reported three cases of multiple papillomata of the larynx treated by topical spraying of antibiotic-steroid combination with the arrest of actively recurring papillomatosis

Both the topical spray of estrogens and the use of antibiotic-steroid combinations in the larynx were employed in Case 4, for a few weeks, without evident effect upon the disease

Schultz[10] in 1908, reported transfer of bovine papilloma to humans Ullman[11] demonstrated a successful inoculation of laryngeal papilloma by means of cell-free filtration extract into the skin of a human, and he also transmitted this as an infectious process to the vaginal mucosa of a dog

More recently, Webb[11] and Pinsker[12] reviewed the literature supporting the possibility of viral etiology of papilloma of the larynx and presented presumptive evidence for the presence of a virus in papilloma Ono[13] and his associates discussed the etiology of multiple papilloma and considered the possibilities of hormonal, chronic irritation, and virus infections in this condition Clinical and experimental observations were thought to point to a virus as the most causative factor Warren[14] indicated that a filtrable agent was responsible for warts, and, furthermore, suggested that a single etiologic agent probably was responsible for the different types of warts, *i e*, cutaneous, genital and laryngeal He stated that warts of dogs and cattle are not transmissible to man

Amarante[15] mentioned studies in progress in vaccinotherapy for recurrent papillomatosis in the adult A general acceptance of the high probability of virus etiology in papilloma of the larynx suggests a possible efficacy of the use of vaccines

Whether papillomatosis was arrested in the cases presented as a result of the use of bovine wart vaccine is open to question Jackson[16] presented multiple papillomata of the larynx as a "benign self-limited disease" He established two classes of cases "*1* Those in which the growth gets well spontaneously, or with slight treatment, surgical or other, and *2* those not readily amenable to any form of treatment, recurrence appearing persistently at the old sites and in entirely new locations" The time required for freedom from recurrences was stated as months, or a year or two

SUMMARY

Four cases of papilloma of the larynx are reported Wart vaccine of bovine origin, as well as other commonly used measures, was employed during the course of treatment

Recurrences of the disease were arrested following administration of vaccine therapy

Further studies are necessary to determine whether the reported cases became arrested fortuitously, or as a result of therapy

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AN EVALUATION OF PATIENTS SUSPECTED OF HAVING NOISE INDUCED HEARING LOSS*

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The term *noise-induced hearing loss* will be used in this paper to refer to the hearing loss that results from repeated exposure to noise over a period of months or years[11] The term, as used here, excludes hearing loss caused by physical trauma to the head or ears, explosion, or excessive changes in barometric pressure

The relationship of hearing loss to noise exposure has been reported by many investigators since the report of Fosbroke in 1831[1,4,5,10,15] Most of these reports are concerned with prolonged exposure to fairly constant sound-pressure levels of moderate intensity Davis[6] was of the opinion that there is no rigid proof of permanent impairment of hearing from noise of less than 115 to 120 db Exposure to 130 to 136 db white noise at the borax wells of Tuscany has caused hearing loss of moderate severity after 100 days of exposure[3]

Jet aircraft engine mechanics and other flight-line personnel are routinely, although intermittently, exposed to high-intensity noise during the performance of their normal duties One present day jet engine produces noise with an overall sound-pressure level of approximately 140 db (see Fig 1) A recent research study of personnel exposed to jet-engine noise failed to show a significant correlation between such exposure and hearing loss, although a positive correlation between age and hearing loss was demonstrated[12]

Barron[2] concluded, "Serial audiometric studies of 470 flight-line mechanics exposed to reciprocating and turbojet engine noise for periods up to seven years while employed in an air-frame manufacturing company are reported There was no

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significant change in the mean or median tests for the group at 1,000 or 4,000 cps frequencies other than those generally associated with presbycusis."

In another report[16] on subjects exposed to jet-engine noise who had been observed for five years, it was concluded that, "There is considerable indication that a certain steady-state jet-engine noise with intensity fluctuations between 90 and 120 db and with sound energy predominantly in the frequencies below 600 cps is not hazardous to the hearing of exposed personnel None of the changes in hearing occurring in any of the subjects in this study can definitely be attributed to exposure to jet-engine noise"

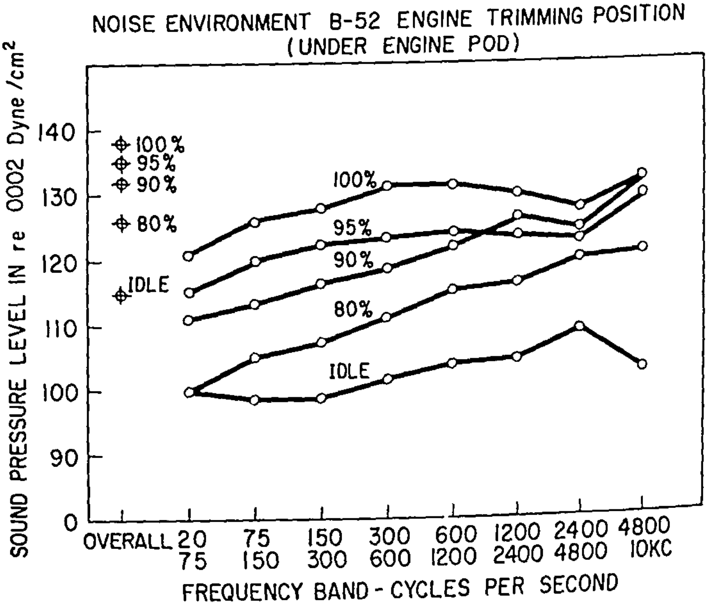

Fig 1

The clinician is frequently called upon to determine whether a patient's hearing level* is caused or aggravated by noise exposure He may be requested to give an opinion as to whether or not continuing at the present job or assignment may cause a change for the worse in the patient's hearing It should be emphasized that studies of the type reported above involve groups of individuals and are not of appreciable assistance in arriving at a correct diagnosis or recommendation for disposition in a specific individual

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*The term "hearing level" is used here in the sense suggested by Davis Hoople and Parrack[7] and refers to ' the deviation in decibels of an individual's threshold of hearing from the American Standard value for the reference zero for audiometers '

This report will point out the importance of obtaining a detailed history, performing a thorough physical examination, and administering hearing tests before making a decision

Because of these early reports it was expected that United States Air Force personnel who are exposed to jet-engine noise would develop hearing loss The requirement for a Hearing Conservation Program was recognized by the United States Air Force and AFR 160-3, first published in 1949 and revised in October, 1956, specifically relates to hazardous noise exposure According to the regulation, the limits for lifetime exposure are as follows·

> "The limits for lifetime exposure to broad band noise are given in terms of the band pressure level for four octave bands The four octave bands are 300 600 c p s 600 1200 c p s, 1200-2400 c p s, and 2400-4800 c p s In setting limits it is assumed that the ears are protected and exposed continuously during normal work hours over a period of twenty five years The risk of damage to hearing is slight when the pressure level of a band does not exceed 85 db It increases as the band pressure level increases and is excessive at 95 db"

The regulation requires that a Hearing Conservation Data Card (AF Form 1490) including a pure-tone threshold audiogram be obtained on everyone suspected of receiving a hazardous noise exposure prior to assignment to his job This baseline audiogram is designated as the reference audiogram As a practical expedient, all individuals who work on the flightline are presumed to receive a hazardous noise exposure The reasons for requiring a pure-tone threshold audiogram, rather than a screening audiogram, has been reported elsewhere[13] The audiometric frequencies required to be tested are 500, 1000, 2000, 3000, 4000, and 6000 cps The regulation specifies that the audiograms be classified as Class A, B, or C Class A means that there is no threshold loss greater than 15 db for any of the above frequencies, in other words, the hearing level is 15 db or better. Class B means that the hearing level is poorer than Class A but not as poor as Class C Class C means that the *hearing level is an average of 20 db or more* for the speech frequencies (500, 1000, and 2000 cps) in *either* ear A copy of AF Form 1490 is sent to the Central Hearing Conservation Data Card Repository at the School of Aviation Medicine, USAF An analysis of 43,536 of these forms, for both military and civilian personnel, reveals the following Class A, 52 per cent, Class B, 43 per cent, Class C, 5 per cent[17] (see Table I) The *breakdown for military* personnel compares favorably with a similar analysis made under research conditions[12] The greater losses in the civilian group is probably due to the advanced age of this group

TABLE I

Unpublished Data from the United States Air Force Hearing Conservation Data Card Repository

	A	B	C	Total
Military—				
	17,923	12,015	934	30,872
	58%	39%	3%	
Civilian—				
	4,434	6,862	1,368	12,664
	35%	54%	11%	

Most flight-line personnel now on duty with the United States Air Force have not had an audiogram prior to noise exposure The current regulation provides that individuals who are now trained and have a Class C classification on their reference (baseline) audiogram should be retested after 15 hours away from noise If the retest shows that the audiogram is still Class C another test is given after 40 hours away from noise If the audiogram remains Class C after 40 hours away from noise, it is recommended that the individual be referred to a Diagnostic Hearing Center for evaluation

This evaluation is to determine whether the individual should be allowed to continue at his present duties or be *transferred* to a noise-safe area which, in all probability, means retraining *in another career field (job)* The transfer of individuals trained for flight-line duties into other career fields could, if a sufficient number are involved, interfere with the Air Force mission Because of the seriousness of this decision it was felt that the evaluation of these individuals with a Class C audiogram or significant threshold shift should be made by a physician with special training in this field of medicine The number of otolaryngologists in the United States Air Force is very limited A hospital is designated as a Diagnostic Hearing Center only when a Board-certified or Board-eligible otolaryngologist is assigned to that hospital It is desirable that a clinical audiologist also be assigned to these Centers The Centers are located throughout the United States and overseas areas so that their services are available without prolonged travel on the part of the patient

The School of Aviation Medicine, USAF, was designated as a Diagnostic Hearing Center October 29, 1956 The author has had the privilege of evaluating a small number of Air Force personnel who were presumed to have received hazardous noise exposures and who were found to have had a Class C audiogram at their duty station They were trained personnel whose length of military service varied from less than one year to over thirty years A reference audiogram was not available on any of the patients

Among the factors considered to be important in the evaluation were the medical history, occupational history, family history, physical examination, hearing tests, estimate of actual noise exposure, and presbycusis

Items considered of particular interest in the medical history were hearing loss since childhood, meningitis or systemic infection, mumps, head injury with drainage of blood from the ear, loss of consciousness or vertigo, injury to the ear from foreign body, blast or blow to the ear, earache, drainage from the ear or decreased hearing associated with a common cold or following aerial flight, medications known to have an effect on hearing, such as streptomycin, dihydrostreptomycin, quinine and others, awareness of hearing loss by the patient and time of onset, and, finally, results of previous physical examinations and hearing tests

The occupational history included military history, hunting or frequent use of firearms, previous employment, particularly concerning noise exposure, present assignment, length of time on the present assignment, tinnitus and/or temporary threshold shift at the end of a work day or work week

The family history was obtained with reference to defective hearing When the history was positive, an evaluation of other members of the family would have been of inestimable value in arriving at a diagnosis

The physical examination was carefully performed Particular attention was given to evidence of disease or injury, active or healed, of the external ear, middle ear, and Eustachian tube, which might affect hearing The fact that fluid in the middle ear may cause a high-tone loss simulating a perceptive loss was kept in mind [11] In unilateral perceptive type cases a caloric test was carried out The effect of age on auditory acuity was considered [1,7]

The hearing tests were performed in a room in which the ambient noise is such that it does not mask the true audiometric thresholds Suitable standards for ambient noise within the test booth have been suggested by the Subcommittee on Noise in Industry of the American Academy of Ophthalmology and Otolaryngology [9]

A pure-tone threshold air conduction and bone conduction audiogram constituted the minimum hearing test The tests were performed on an audiometer which was calibrated according to the specifications prepared by the American Standards Association Speech reception threshold and discrimination tests are an invaluable adjunct in evaluating the patient's hearing for speech Speech tests were done whenever indicated The speech reception threshold was obtained using laboratory equipment and the W-2 recordings The discrimination score was obtained using the same equipment and Russ-Hughes recordings The scores on normal individuals in our laboratory range between 75 per cent and 85 per cent A recruitment test may aid in differentiating between cochlear and retrocochlear perceptive type losses, however, it is a difficult test to perform when the loss in both ears is equal All tests were performed by an individual with special training in hearing testing

As a result of procedures such as those outlined above, 77 cases referred to the Diagnostic Hearing Center, School of Aviation Medicine, USAF, were diagnosed as follows

1 Conductive		29
a Otitis media chronic (active or healed)	11	
b Otosclerosis	17	
c Atresia external auditory meatus congenital	1	
2 Functional		7
a Psychogenic	2	
b Voluntary (Malingerer)	5	
3 Perceptive		41
a Unilateral	22	
b Bilateral	19	

COMMENTS

It was felt that noise exposure definitely was not the main cause for a Class C audiogram in the conductive cases

With reference to the functional cases, the hearing level of the two psychogenic cases may have been contributed to indirectly by noise exposure, but a basic psychiatric disturbance was in operation The five diagnosed as voluntary functional cases were found to have essentially normal hearing after repeated tests

The perceptive type cases were categorized as being unilateral or bilateral Medical histories of the unilateral perceptive cases were revealing Of the 22 unilateral cases, nine patients gave a history of head injury with loss of consciousness and each was aware of defective hearing following it, nine gave a history of defective hearing since childhood, cause unknown, one patient had experienced a sudden loss of hearing while on furlough, and three could not date the onset of defective hearing although each individual stated that he had been aware of it for several years One patient who had no history of head trauma had an absent caloric response and unilateral deafness He was referred for a neurological consultation because of the possibility of acoustic neuroma In none of the unilateral perceptive types was noise exposure felt to be the main cause for a Class C audiogram

Since only the bilateral perceptive type cases are now temporary threshold shift at the end of a work day or work week

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Since only the bilateral perceptive type cases are now suspected of noise-induced hearing loss, it is felt that a presentation of the audiometric findings and a brief extract of the pertinent history of these cases is in order

Case 1 F W E, M/Sgt, age 38 The patient worked as a conventional aircraft mechanic from 1942 to 1956 During 1956 and 1957 he was "line chief" for a squadron of F 89's He first noted hearing loss nine months ago

		250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC	Right	25	25	25	25	50	65	NR	NR	17	78
	Left	20	25	30	35	60	65	NR	NR	24	80
BC	Right	20	20	20	20	NR	NR				
	Left	20	20	40	35	NR	NR				

Case 2 C B R, civilian, age 42 The patient has worked as a conventional aircraft mechanic for 17 years Defective hearing was noted during his physical examination for separation from the Navy in 1945 He does not feel handicapped socially or at work by defective hearing He gives no history of temporary threshold shift after a work day

		250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC	Right	5	20	60	NR	NR	NR	NR	NR	46	24
	Left	0	15	65	NR	NR	NR	NR	NR	45	22
BC	Right	5	10	65	NR	NR	NR				
	Left	10	20	65	NR	NR	NR				

Case 3 J D P, T/Sgt, age 34 The patient has 16 years' military service He was a conventional aircraft mechanic until 1955 Since then he has been a jet mechanic He has noted defective hearing for several years

		250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC	Right	0	15	35	65	75	80	70	55	36	44
	Left	0	15	45	65	75	75	NR	55	36	52
BC	Right	0	25	30	NR	NR	NR				
	Left	–10	30	45	NR	NR	NR				

Case 4 R A Z, A/2C age 22 The patient was exposed to considerable heavy weapons fire while in an Army artillery division during the Korean Conflict He noted defective hearing and tinnitus at the time of discharge from the Army He enlisted in the United States Air Force April 22, 1957

		250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC	Right	25	40	35	40	65	70	70	40	37	70
	Left	25	35	40	40	65	75	75	50	35	64
BC	Right	30	45	35	35	NR	NR				
	Left	25	35	35	35	NR	NR				

Case 5 A B M, civilian, age 58 The patient retired from the Army in 1950 after 30 years' active service He has fired small weapons frequently all his life He worked as a conventional aircraft mechanic during most of his military career Since retirement he has worked as a Civil Service employee doing the same type of work

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC Right	10	20	40	55	65	60	55	45	34	52
Left	5	30	50	60	65	60	55	55	41	44
BC Right	–10	–10	20	50	NR					
Left	–10	–10	40	55	NR	NR				

Case 6 E R, civilian, age 44 The patient has been a conventional aircraft mechanic for 12 years He has noted defective hearing for two or three years

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC Right	0	10	25	50	70	60	40	45	32	60
Left	10	10	30	60	70	65	50	55	30	52
BC-Right	10	20	30	50	NR	NR				
Left	10	0	15	NR	NR	NR				

Case 7 R M M, civilian age 54 The patient has been a conventional aircraft mechanic for the past 11 years There is no other history of noise exposure He occasionally has high pitched tinnitus

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC Right	15	15	25	35	45	50	55	20	25	68
Left	5	10	20	30	45	50	50	30	20	88
BC-Right	20	30	35	35	40	45				
Left	10	20	30	35	45	40				

Case 8 R H H, M/Sgt, age 50 The patient has 16 years' military service He was in the infantry for 15 months in World War II during which time he was frequently exposed to machine gun carbine, and howitzer fire He has been aware of defective hearing since 1945

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC Right	10	25	35	45	60	75	65	70	24	72
Left	15	30	40	65	65	75	60	65	43	52
BC-Right	15	25	35	50	NR	NR				
Left	20	35	45	NR	NR	NR				

Case 9 R O B, A/2C, age 26 While he was in the Army in 1951, a 90 or 120 mm howitzer was fired near the patient He had tinnitus for eight hours following this He hunts frequently From December 1956 to June, 1957, he was exposed almost daily to small arms fire on a rifle range Since June, 1957 he has been exposed to jet aircraft noise

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC-Right	20	30	30	35	55	60	60	55	36	64
Left	35	35	35	35	60	60	65	55	38	60
BC-Right	25	35	35	45	55	55				
Left	25	30	30	35	60	55				

Case 10 W F F, S/Sgt, age 27 The patient was a weapons mechanic for eight and one half years He first noted defective hearing while in Korea in 1951 He was bore-sighting 50 calibre machine guns on F-86 type aircraft He was exposed to 8 000 to 13,000 rounds a day for one year He had tinnitus for two or three hours every evening but noted no temporary threshold shift

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC - Right	15	20	40	60	55	50	50	50	24	48
Left	20	15	25	50	55	55	55	40	23	70
BC - Right	15	15	40	50	55	50				
Left	5	15	40	30	55	45				

Case 11 D J F , A/3C, age 21 The patient has had 38 months' service in the United States Air Force He has done armament work for 12 months He fires small arms frequently He has had pure tone type tinnitus since childhood and has had recurrent episodes of otitis media He had a simple mastoidectomy on the left as a child Examination revealed marked scarring of the tympanic membranes

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC - Right	15	25	30	20	70	70	60	55	28	76
Left	15	20	25	45	75	75	70	50	33	66
BC - Right	5	10	20	20	NR	NR				
Left	–	5	30	35	NR	NR				

Case 12 D D F , S/Sgt , age 23 The patient has been a jet mechanic for five and one half years His grandmother wears a hearing aid There has been no significant change in his audiogram between May, 1957, and December, 1957

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC - Right	–5	10	20	50	50	45	35	35	18	66
Left	–10	5	15	50	50	50	40	40	13	82
BC - Right		10	20	50	55	NR				
Left		10	20	NR	NR	NR				

Case 13 H A S , M/Sgt , age 36 The patient developed a "humming, buzzing-type ringing" in the left ear following a flight from Japan to California in October, 1957 The patient has been aware of defective hearing since then His father has defective hearing

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC - Right	15	20	45	45	50	55	65	30	41	54
Left	15	15	35	50	65	60	65	45	43	48
BC - Right	20	35	50	35	NR	45				
Left	20	20	30	NR	NR	NR				

Case 14 H W N , S/Sgt , age 48 The patient has had 15 years' military service He was assigned with the Air Police for three years but rarely fired a weapon For the past three months he has worked in a hangar close to T-37 type operating aircraft He is unaware of defective hearing He rarely flies His father has defective hearing

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC - Right	0	10	20	25	50	65	70	80	18	86
Left	0	10	25	25	40	40	50	55	25	82
BC - Right	10	15	20	30	55	NR				
Left	5	–5	5	30	40	55				

Case 15 R C , T/Sgt , age 27 From 1947 to 1955 the patient worked as a mechanic on conventional aircraft During 1955 and 1956, he was a

mechanic on the B 47 type multiple jet bomber He has had no serious noise exposure since 1956 Both parents have defective hearing

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC Right	55	70	65	60	65	55	50	45	67	50
Left	35	35	40	25	25	25	15	30	37	44
BC Right	35	25	50	50	50	45				
Left	15	15	25	30	30	15				

Case 16 M W B, T/Sgt, age 28 The patient quit a job in a factory while in high school because the noise made him nervous In 1949 he had mumps During his hospitalization an audiogram was performed and revealed defective hearing His father had defective hearing at an early age He has a brother and sister who have defective hearing The paternal grandfather has defective hearing

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC - Right	20	20	30	45	50	55	50	45	37	44
Left	10	20	30	45	50	55	55	45	32	48
BC Right	-	25	30	NR	NR	45				
Left		25	35	45	45	50				

Case 17 M R C, A/1C, age 25 When the patient was 12 years old, a firecracker accidentally exploded close to his ear He had temporary threshold shift and tinnitus for several hours afterward Prior to entering the United States Air Force he was employed for six years in aircraft companies as a sheet metal worker, riveter and punch press operator He operated a jack hammer for six months He is now a B 36 mechanic but is rarely exposed to noise

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC - Right	–5	–5	–5	15	75	75	75	50	5	50
Left	15	25	NR	NR	NR					
BC - Right	0	0	–10	15						
Left	20	15	NR	NR						

Case 18 W J B, A/2C age 22 The patient is an air policeman who works as a security guard on the flight line He was an aircraft mechanic in the Navy from 1952 to 1955 He is unaware of defective hearing In 1949 he had a head injury which resulted in loss of consciousness for 20 minutes

	250	500	1000	2000	3000	4000	6000	8000	SRT	Discrimination
AC - Right	10	15	20	25	50	50	30	40	19	60
Left	0	10	20	20	30	30	20	25	14	74
BC - Right	5	0	20	25	55	40				
Left	5	10	25	30	20	25				

Case 19 M L H, S/Sgt, age 26 The patient has six years' military service During this period he has done aircraft sheet metal work and used riveting machines and sheet metal presses He has noted some difficulty in understanding speech for about two years He does not feel that his hearing loss is progressive At age 15 he had a head injury with loss of consciousness for two minutes

		250	*500*	*1000*	*2000*	*3000*	*4000*	*6000*	*8000*	*SRT*	*Discrimination*
AC	Right	–5	–5	10	70	75	80	NR	NR	13	72
	Left	–5	5	15	60	75	95	NR	80	13	50
BC	Right	0	–10	5	NR	NR	NR				
	Left	0	10	15	NR	NR	NR				

DISCUSSION

Inasmuch as reference audiograms had not been done on these patients, it was impossible to determine whether there had been a threshold shift (Since March 10, 1957, every individual entering the United States Air Force has had a pure-tone threshold audiogram as part of his routine physical examination) The audiometric curves obtained on many of the patients were not of the type usually found in noise-induced hearing loss

It is suspected that poor hearing probably had been present for many years in those patients who stated that they were unaware of hearing loss A family history of hearing loss was obtained from a few of them At present, it is impossible to determine whether most of these patients had actually received a hazardous noise exposure With equipment now available, the duration of an individual's exposure to a given sound-pressure level on a flight-line can not be measured conveniently or accurately because the noise level fluctuates almost continually, and personnel move into and out of the noise areas sporadically Most of these patients were returned to their previous assignments All of them were urged to wear ear protection, and they were requested to return in one year for further evaluation It is hoped that an evaluation of these individuals after they have been an additional year at their normal place of duty will prove rewarding

SUMMARY

The results of an evaluation of 77 United States Air Force flight-line personnel with defective hearing are reported The evaluation revealed that 29 patients had a conductive type, seven had a functional type, and 41 had a perceptive type defect Twenty-two of these perceptive cases were unilateral In only 19 cases was noise exposure considered to be a possible cause of defective hearing The difficulties encountered in attempting to determine whether defective hearing in a specific patient is caused or aggravated by noise exposure are discussed

CONCLUSIONS

The greatest difficulty encountered in evaluating these patients was the lack of a reference audiogram Until a method or a device is developed to measure the noise exposure each individual receives, or until it is proved that intermittent exposure to high-intensity noise causes hearing loss, the judgment of the examining physician will be greatly taxed in determining whether the hearing level in a specific patient is caused or aggravated by noise exposure but, careful history-taking and medical examination are needed to rule out other influences By obtaining detailed histories, performing thorough physical examinations, and administering hearing tests, it was possible to eliminate 58 out of 77 patients with Class C hearing who were suspected of having a noise-induced hearing loss

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School of Aviation Medicine, USAF
Brooks Air Force Base, Tex

AMERICAN SOCIETY OF FACIAL PLASTIC SURGERY

The meeting of the American Society of Facial Plastic Surgery will be held December 9, 1959, at the Hotel Elysee, 60 East 54th Street, New York City

Program Plastic Surgical Management of Facial Lesions, by Bernard E Simon, M D , Dermabrasion—A Re-appraisal by Irwin I Lubowe, M D , Discussion, Norman Orentreich, M D

PB INTELLIGIBILITY AND WORD FAMILIARITY

CHARLES HUTTON, Ph D ,[*]
and
JOHN WEAVER, B S ,[†]
Champaign, Ill

In the construction of the original PB-lists by Egan,[3] the variables given primary consideration were phonetic content and word familiarity When the lists became popular in hearing testing, clinical observations indicated that there were still many unfamiliar words, necessitating modifications such as that by Haskins[4] and Hudgins[7] In the revision and re-recording of the PB-lists by Hirsh et al ,[5] further attempts were made to equalize word familiarity, however, because of the recent finding by Howes[6] that familiarity is the single most important variable in word intelligibility, it would seem that more attention should be given to this aspect of test construction Further, if it is assumed that the relative frequency of occurrence is the best index of word familiarity, it should be noted that specific information about word familiarity is available, spanning the pre-school age,[1] elementary age,[8] and adult age levels[9] The present study is an attempt, prompted by clinical observation, to examine variations in word familiarity of the PB W-22 word lists at these lower age levels

PROCEDURE

The 200 words in the PB W-22 lists[5] were ranked according to frequency of occurrence in the Thorndike-Lorge general count[9] and the total occurrence in Rinsland's elementary school list[8] The words chosen for this study are presented in Table I and consist of the 15 words that were rated highest and the 15 words that were rated lowest in frequency of occur-

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TABLE I

The 15 Most Familiar and the 15 Least Familiar PB W 22 Words According to the Thorndike Lorge General Count and the Rinsland Total Count

PB Word	Thorndike-Lorge*	Rinsland†
and	AA	203,146
you	AA	102,426
we	AA	93,444
in	AA	88,782
it	AA	83,344
of	AA	81,620
is	AA	79,025
have	AA	57,102
my	AA	55,267
are	AA	49,699
he	AA	47,225
on	AA	42,058
they	AA	41,863
that	AA	39,497
she	AA	31,361
tan	14	166
jam	16	109
chew	14	102
ache	28	100
ham	17	84
chin	27	67
jaw	11	58
carve	26	54
knit	30	53
deaf	19	47
ail	5	0
shove	15	26
darn	12	18
pew	5	0
ace	3	0

*The number of occurrences per million words, AA is the highest rating given and indicates 100 or more occurrences per million

†The number of times the word occurs in the first eight grades

rience Rather arbitrary decisions were made concerning the choice of several of the least familiar words Examination of the phonetic content of these two sets of words indicates that the more familiar words have a smaller number of phonemes and a smaller vowel to consonant ratio, both of which should operate to increase word intelligibility

Fifty-three public school students were used as subjects, all of whom were receiving speech therapy at the time of the study Two students were hard of hearing, the remaining 51 had normal hearing by pure frequency audiometry Four of the subjects were in kindergarten, 22 in the first grade, nine from the second grade, three seventh graders, two eighth, one ninth, two tenth, five eleventh, and five twelfth graders All had normal intelligence

The students were brought in, one at a time, to a sound-treated therapy room for testing purposes The 30 words were presented at a conversational level, live voice, in a random order by the junior author, who was the speech correctionist for the students Each listener was told that he would be given a listening test consisting of 30 words The speaker said each word only once and the listener was instructed to repeat the word he heard The speaker wrote down the response to each stimulus word Because of the sometimes complicating speech defects of the subjects, responses were quantified in the following manner When the response was not clearly audible or was distorted, the subject was asked to explain the meaning of the word For example, if the stimulus word was "carve" and the listener's response was "car," he was asked to explain the word he had just said If the explanation was that it was something to ride in, then a "car" response was recorded as an error, however, if the explanation was that it was something you do with a knife then "car" was recorded as a correct response

RESULTS

The number of times each of the 30 words was incorrectly identified is presented in Table II It can be seen that only three of the most familiar words were missed more than once, while 14 of the 15 least familiar words were missed more than once Application of the sign test[2] indicates that the differences in number of incorrect responses between the two sets of words are significant at the 1 per cent level It seems unlikely that the differences in phonetic content of the two lists could produce such results Examination of the nine grade columns shows that most of the response errors took place at the lower three grade levels, in fact, all of the 19 errors on the most familiar words and about three-fourths of the errors on the least familiar words occurred at the kindergarten and first grade levels The regularity of the age effect

TABLE II

Number of Incorrect Reponses for the 15 Most Familiar and the 15 Least Familiar Words in the PB W-22 List

										Sum
Number of Listeners	4	22	9	3	2	1	2	5	5	53
				Grade						
PB Word	Kind	1	2	7	8	9	10	11	12	
and	1	2	0	0	0	0	0	0	0	3
you	0	0	0	0	0	0	0	0	0	0
we	0	0	0	0	0	0	0	0	0	0
in	1	0	0	0	0	0	0	0	0	1
it	0	1	0	0	0	0	0	0	0	1
of	0	1	0	0	0	0	0	0	0	1
is	0	1	0	0	0	0	0	0	0	1
have	2	1	0	0	0	0	0	0	0	3
my	0	0	0	0	0	0	0	0	0	0
are	0	0	0	0	0	0	0	0	0	0
he	1	0	0	0	0	0	0	0	0	1
on	0	0	0	0	0	0	0	0	0	0
they	1	5	0	0	0	0	0	0	0	6
that	0	1	0	0	0	0	0	0	0	1
she	0	1	0	0	0	0	0	0	0	1
										19
Errors/listener	1 5	0 6	0	0	0	0	0	0	0	
tan	4	8	3	0	0	0	0	0	0	15
jam	1	15	3	0	0	1	0	1	0	21
chew	0	5	1	0	0	0	0	0	0	6
ache	3	8	1	0	0	0	0	0	0	12
ham	1	3	0	0	0	0	0	0	0	4
chin	0	0	0	0	0	0	0	0	0	0
jaw	3	13	5	0	0	0	0	1	1	23
carve	4	22	5	0	0	1	0	0	0	32
knit	2	9	2	0	0	0	0	0	0	12
deaf	3	15	7	2	0	1	1	2	3	34
ail	4	10	4	0	0	0	0	0	0	17
shove	3	11	3	0	0	0	0	0	0	17
darn	4	19	6	0	0	0	0	0	0	29
pew	3	11	2	0	0	0	0	0	0	16
ace	1	4	1	1	0	0	0	0	0	7
										247
Errors/listener	9 0	7 0	4 8	1 0	0	3 0	5	8	8	

can be seen in the tendency toward a decrease in number of errors per child as grade level increased

While there are other words in the PB W-22 word lists that are low in frequency of occurrence, the above results seem to indicate that differences in word familiarity on these lists would usually not have a large effect on discrimination scores at higher age levels, however, at kindergarten and lower elementary grade levels, there are substantial differences between the two word familiarity extremes. In the writers' opinion the size of these differences is great enough to cause serious concern about the use of the PB W-22 lists and recordings in hearing testing at lower age levels. In addition to the above data, it should be noted that while 135 of the 200 W-22 words are AA words, many of these, *e.g.*

TABLE III

Number of Incorrect Responses on the Least Familiar and the Most Familiar PB W-22 Words for Individual Listeners at the Lower Three Grade Levels

Listener	Kindergarten Least	Kindergarten Most	First Grade Least	First Grade Most	Second Grade Least	Second Grade Mos
1	10	1	11*	0	7	0
2	9	4	10	1	6	0
3	8	1	10	1	6	0
4		0	10	1	5	0
5			9	0	5	0
6			8	2	5	0
7			8	2	4	0
8			8	0	4	0
9			8	0	1*	0
10			8	0		
11			7	0		
12			7	0		
13			6	0		
14			6	0		
15			6	0		
16			5	3		
17			5	1		
18			5	0		
19			5	0		
20			4	1		
21			4	0		
22			3	1		

*Hearing of Hearing

else," are unfamiliar to children. Of course, the clinician who is testing children can use such procedures as trying to teach the unfamiliar words to the client prior to testing, but such procedures are at best, time consuming, and of doubtful validity with hearing-handicapped children.

Further demonstration of the differences between the least familiar and most familiar PB words can be seen by examining the listener data for the three lower grade levels. While it is apparent from inspection of Table II that the small number of errors on the most familiar words would not produce large differences between individual listeners, the data in Table III indicate that there are substantial differences between listeners on the least familiar words. It would seem unlikely that these differences could be due to variations in sound discrimination ability among the listeners, since the rank positions of the listeners on the two sets of words are substantially different. For instance, in the first grade the first seven listeners made seven errors on the most familiar words,

TABLE IV

Number of More Familiar and Less Familiar Responses on the 15 Least Familiar PB W 22 Words. Ratings Based on the Thorndike Lorge General Count, Responses for the Lower Three Grade Levels. Responses (Incorrect) Grades Kindergarten, One and Two

PB Word	More	Less	Total
tan	14	0	14
jam	18	1	19
chew	6	0	6
ache	10	2	12
ham	4	0	4
chin	0	0	0
jaw	21	0	21
carve	30	1	31
knit	10	2	12
deaf	22	3	25
ail	18	0	18
shove	16	1	17
darn	29	0	29
pew	11	5	16
ace	5	1	6
	214	16	230

the middle eight listeners made no errors on these words, and the last seven listeners made six errors. At the same time the number of errors on the least familiar words was progressively decreasing. Thus the least familiar words did not distinguish between listeners in the same direction as the most familiar words. The explanation for this would seem to be that the least familiar words test the vocabulary as well as the sound discrimination ability of the client. In multiple presentations, as in hearing aid evaluations, we may, in part, be testing the client's ability to use new words quickly. Perhaps these data may be a partial explanation for the variability encountered in some testing situations

An indication of the importance attached to word familiarity by the listener can be found by looking at their incorrect responses The response errors, except for word fragments, to the least familiar words are summarized in Table IV Only the data for the lower three grade levels are reported here The frequency of occurrence of each of the incorrect responses was located in the Thorndike-Lorge general count and compared with the rating of the stimulus word In 214 out of 230 such comparisons, the response word was more familiar than the stimulus word Similar results were found using rankings from Rinsland Certainly, this is a clear indication of the confounding effect of word familiarity in discrimination testing with PB words

SUMMARY AND CONCLUSIONS

In an attempt to quantify clinical observations about unfamiliar words in the PB W-22 lists, the 15 least familiar and 15 most familiar words were presented to a group of 53 public school students from kindergarten age to twelfth grade The conclusions are as follows

1 The 15 least familiar words were less intelligible than the 15 most familiar words

2 Intelligibility increased as age increased, especially for the least familiar words at lower age levels

3 The least familiar words did not distinguish between listeners in the same direction as the most familiar words

4 The incorrect responses to the least familiar words were higher in frequency of occurrence than the PB words, a further indication of the confounding effect of word familiarity on discrimination testing

5 These data cast serious doubt on the use of the PB W-22 words at pre-school and lower elementary school ages It is suggested that these data may also be a partial explanation for the variability encountered in some clinical situations

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328 Illini Hall

TEMPLE UNIVERSITY POSTGRADUATE COURSES

Postgraduate course in laryngology and laryngeal surgery, April 4th to 15th, and September 26th to October 7th, 1960

Postgraduate course in bronchoesophagology, February 1st to 12th, and November 7th to 18th, 1960

These courses are to be given in the Department of Laryngology and Bronchoesophagology, Temple University Medical Center, under the direction of Drs Chevalier L Jackson and Charles M Norris

The tuition fee for each course is $250 Application and information may be obtained by writing to Jackson-Research, Lab 604, Temple University Medical School, 3400 N Broad street, Philadelphia 40, Pa

A TECHNIQUE FOR SPLINTING FRACTURES OF THE STAPES CRURA*

DAVID MYERS, M D,

Philadelphia, Pa

One of the frequent complications in mobilization of the stapes, whatever the technique employed, is a fracture of one or both of the crura This is a very distressing complication, since it will nullify any good results obtained by mobilization In a number of patients, fracture of one of the crura was united with and splinted by means of a minute piece of plastic tubing, which was used to surround the fractured crura and hold it together This technique is submitted for your consideration

Case 1 Mrs G had a previous mobilization procedure three-and-one-half years ago At that time, the Zeiss loupe was used for magnification I thought that mobility had been achieved, without greater magnification however I was unable to inspect the entire footplate and ossicular chain The patient's hearing did not improve postoperatively, and she was not seen again until she returned for revision on Dec 19, 1958 At the operation it was found that this patient had a localized otosclerosis which involved the anterior crus (Grade I, Bellucci) After careful dissection, using the 16X power of the Zeiss operating microscope, it was revealed that what was thought to be mobility at the first operation was actually a fracture of the posterior crus in its lower third With the use of a small chisel, the entire footplate was freed Good mobility was visualized and the patient's hearing improved immediately, however, a fracture of the anterior crus also resulted. Because of the considerable motility of the crura due to the fractured crura, the idea occurred that I might be able to splint the fracture of the posterior crus I fashioned a piece of No 90 plastic tubing (see Fig 1) and found that this would easily fit around the fractured crus The tube was made long enough so that it touched the footplate and lenticular process of the incus Once the tube was applied it embraced the posterior crus surrounded it and held it firmly The plastic tubing is elastic and contracts after it is applied The patient's hearing increased tremendously because of the improved columellar effect and an excellent result was obtained (see Fig 2)

Case 2 Mrs H.A. This patient had a Grade II otosclerosis The surgical technique employed was that of anterior crurotomy When pressure with the Shea anterior crurotomy knife was applied a shearing action took place which twisted and fractured the posterior crus just above the junction with the footplate The mucosal covering of the stapes held the fracture together, but the entire joint was very feeble since

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*From the Department of Otorhinology Temple University Medical Center

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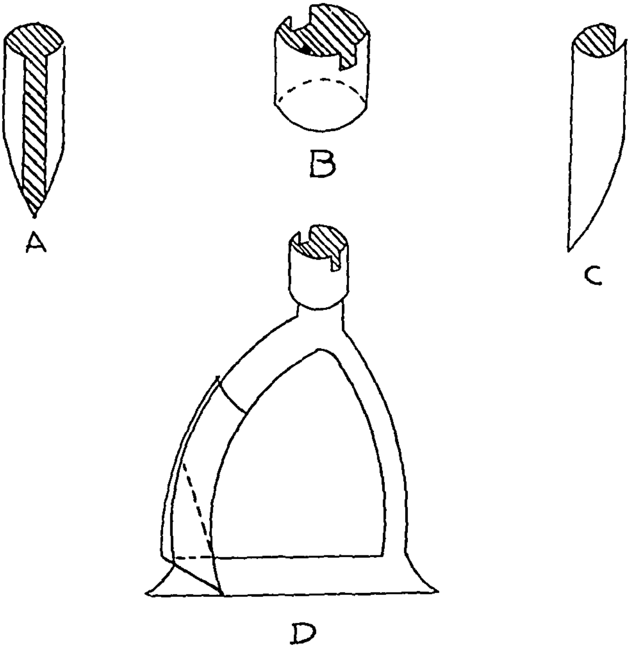

Fig 1 a and c—Diagrammatic sketch indicates shape of plastic splint The shape and cut can be varied with the location of the fracture d—Indicates mode of application b—indicates a plastic couplet used to unite the disarticulated incus and stapes

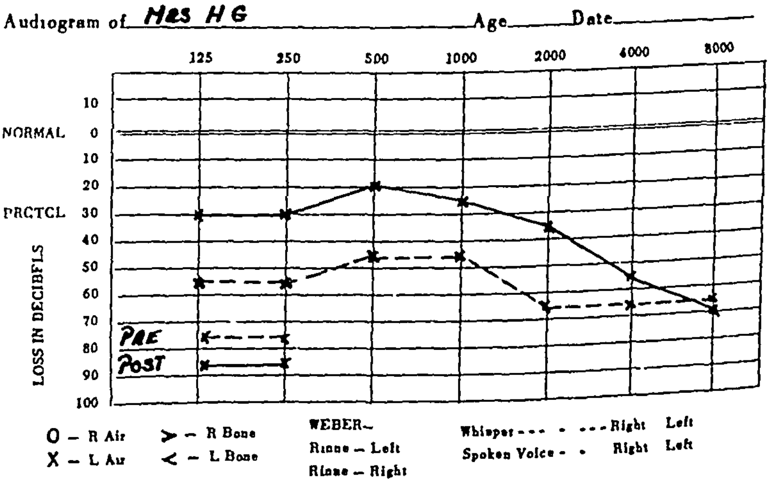

Fig 2

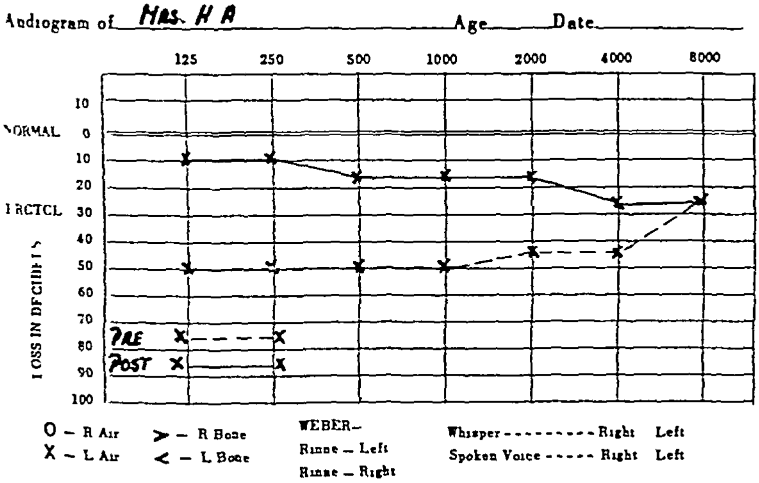

Fig 3

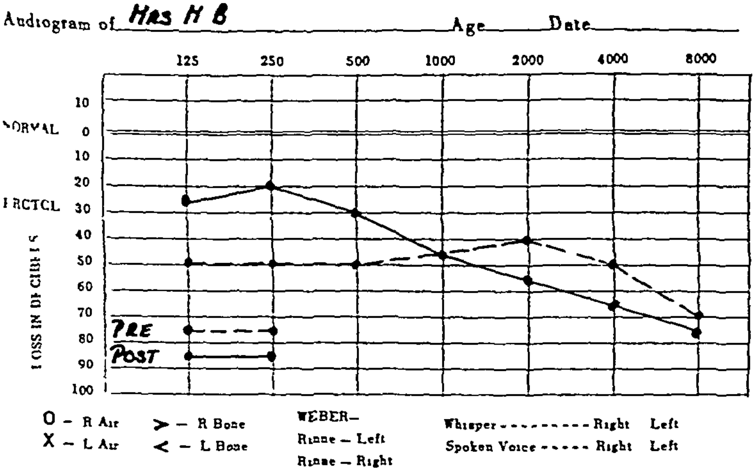

Fig 4

both crura were now fractured Utilizing the experience of Case 1, a minute piece of plastic tubing was used and fashioned to form a splint The posterior border of the fossa ovalis could be outlined The end of the plastic splint was pointed and inserted into the joint and used to surround the crura This held perfectly and the patient's hearing improved (see Fig 3)

Case 3 Mrs B In this patient a stapes mobilization had been carried out on April 28 1956 There was no improvement of hearing despite the fact that I thought I had achieved mobilization On revision, with the use of the Zeiss microscope and adequate magnification, it was discovered that there actually was a fracture of the posterior crus and disarticulation of the stapes from the incus There was localized otosclerosis The footplate was cut free, a splint was applied to the posterior crus, and a couplet to the stapes head, which was notched so that the incus could fit into it When the columellar effect of the stapes was re united, the patient's hearing improved (see Fig 4)

CONCLUSION.

A technique is presented in which No 90 plastic tubing is used to repair fractures of the crura A splint is made with plastic tubing and used to surround the fractured crura This can be carried out with relative ease and is a technique which can be used to salvage cases in which this complication occurred It is also possible to use this idea to unite the disarticulated incudostapedial articulation by fashioning a couplet to unite these two fractures The idea developed after I had developed a facility with this tubing after using it during the performance of the Shea vein graft technique

3701 N Broad Street

ANNOUNCEMENT

The Annual Spring Meeting of the Alumni Association of the New York Eye and Ear Infirmary will take place April 4-7, 1960

The meeting will be oriented towards pediatric otolaryngology Symposia will be offered on Nystagmus as a Pediatric Problem, Diagnosis and Rehabilitation of Hearing Problems in Children, and Ankylosis of the Stapes There will also be a closed circuit television demonstration of surgical procedures In addition, courses will be offered in Allergy and Immunology in Children, X-ray Diagnosis in Ear and Sinus Problems in Children, Pediatric Laryngeal Problems, and Secretory Otitis Media in Children

Additional information may be obtained by writing to Dr John R Finlay, Secretary, Alumni Association, 218 Second avenue, New York 3, N Y

A MODIFIED AURAL SPECULUM FOR USE DURING MYRINGOTOMY

MERRILL LINEBACK, M D ,

College Park, Ga

Frequently during the performance of a myringotomy the depths of the canal will fill with blood from the incised drum and completely obscure it When this occurs, the procedure must be stopped and an adrenalin-soaked sponge or gauze triangle tip placed deep in the canal until bleeding ceases

It was with this situation in mind that the medium sized aperture Gruber aural speculum was modified by having a No 14 needle silver-soldered to the outside at the site of greater diameter at the distal end The needle is cut flush with each end of the speculum (see Fig 1, No 1) Through this outside needle is passed a short length of Adams polyethylene tubing PE-90 which fits snugly To the proximal end of the tubing a No 20 needle is slipped, as shown at No 2 in Fig 1. To the proximal end of this needle is attached a House adapter as shown at No 3 When the assembled unit is attached to rubber tubing and to the lower arm of the "Y," shown at No 4 in Fig 2, it will provide the suction and aspiration necessary to remove obscuring blood Since the polyethylene tubing slips easily through the No 18 needle, the depth of placement can readily be modified to suit the infant or adult canal

The paracentesis end of the opposite arm of the "Y" consists of the Senturia aspirator, No. 2, Fig 2, to which is attached a No 19 spinal needle The base of the "Y" attaches either to wall suction or to aspirating machine The cut-offs, No 3 and No 5, are used to prevent or allow suction as needed

When in place, the outside soldered needle lies along the inferior part of the external canal The Storz magnifying operating loupe may be used with the speculum to provide

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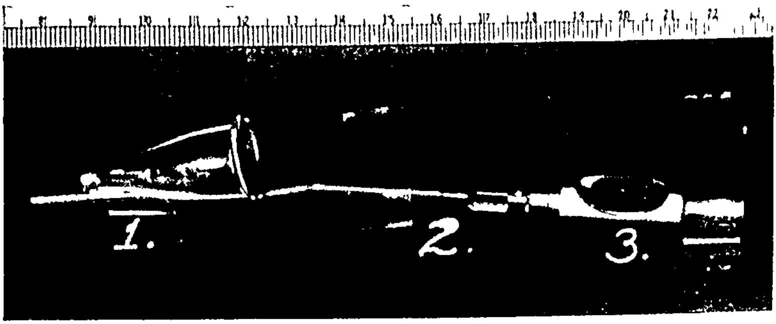

Fig. 1. The modified Gruber medium sized speculum with a No. 14 needle silver-soldered on the outside as shown at 1. At 2 is the Adams PE 90 tubing with a No. 20 needle inserted and at 3 is the House connector.

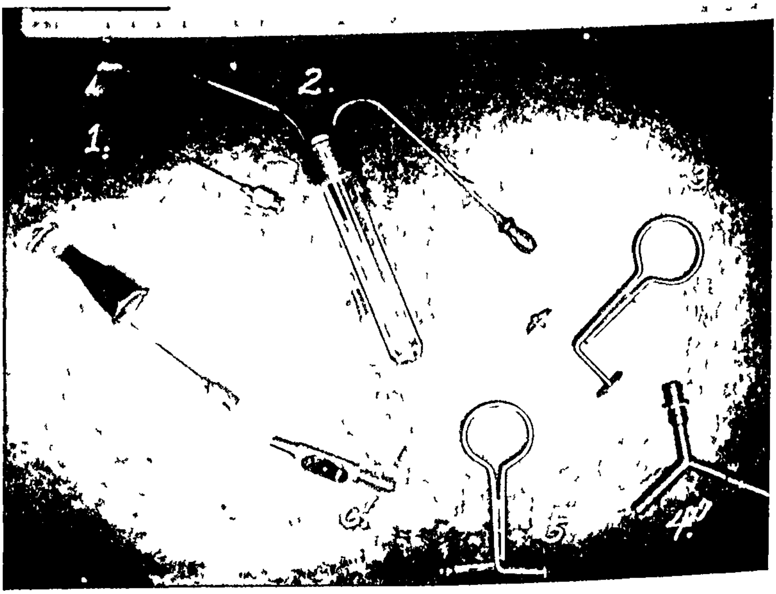

Fig. 2. The author's set-up for suction during myringotomy and paracentesis. 1, 2 and 3 is the modified Senturia suction biopsy and aspiration end of the "Y", at 5, 6 and 7 is the new modification suction speculum to maintain a dry field in the canal depths. The rubber tubing is omitted for clarity.

more precise viewing of the drum head. The modified speculum should prove useful during tympanoplasties and possibly the transtympanic approach to the labyrinth and stapes by simply turning the speculum 180 degrees so that the tubing now lies in the superior area of the external canal. By the same token, application of liquid medication is facilitated during the treatment of infections deep in the external canal also involving the myrinx This modification of the Gruber aural speculum is obtainable from the Storz Instrument Company, 4570 Audubon Ave, St Louis 10, Mo and from Estes Surgical Supply Co, 56 Auburn Ave, N E, Atlanta Ga

124 West Princeton Avenue

POSTGRADUATE COURSE

The next postgraduate course in Laryngology and Broncho-esophagology to be given by the University of Illinois College of Medicine is scheduled for the period April 4 to 16, 1960 The course is under the direction of Dr Paul H Holinger

Interested registrants will please write directly to the Department of Otolaryngology, University of Illinois College of Medicine, 1853 West Polk Street Chicago 12, Ill

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THE VENTRICULOMASTOID SHUNT.*†

CLIFFORD F. LAKE, M.D.,
Rochester, Minn.

The patient who has increased intracranial pressure associated with obstructive or communicating hydrocephalus offers a distinct challenge from the surgical standpoint.

REVIEW OF LITERATURE

Many procedures have been performed to shunt cerebrospinal fluid into various parts of the body. Davidoff[1] in 1929, reviewed the treatment of hydrocephalus from ancient to modern times. Three years later, Davidoff and Bancroft[2] reported a case in which a ureterodural anastomosis had been performed for hydrocephalus. These authors credited Heile,[3] who wrote in 1925, as being the first to report on ureterodural anastomosis following unilateral nephrectomy for the treatment of hydrocephalus. Lehman,[4] in 1934 described his experiences with uretero-arachnoid anastomosis in three cases. Matson,[5] in 1949, presented a case report and description of arachnoid-ureterostomy via a polythene tube and,[6] in 1951, reported the successful relief of increased intracranial pressure in four children by ventriculo-ureterostomy.

Nosik,[7] in 1950, described the technique of ventriculomastoidectomy which he first performed on March 28, 1947. His technique consisted of shunting the cerebrospinal fluid

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*Presented as a Candidate's Thesis to the American Laryngological, Rhinological and Otological Society, Inc., 1959.

†From the Section of Otolaryngology and Rhinology, Mayo Clinic and Mayo Foundation.

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from the lateral ventricle to the mastoid antrum He made a cranial incision, inserted one end of a polythene tube into the ventricle and introduced the other end into the mastoid antrum through the petrous surface of the mastoid In another article, also published in 1950,[8] he presented a case of marked hydrocephalus for which ventriculomastoidostomy had been performed three years previously

Svien, Dodge, and Lake,[9] in 1952, described a modification of Nosik's operation This also consisted of shunting the cerebrospinal fluid via a polythene tube, one end of which was inserted into the posterior horn of the lateral ventricle through a burr hole They then brought the tube under the scalp to a second incision over the mastoid process and inserted the other end into the mastoid antrum after removal of enough mastoid cells to permit its entrance These authors reported the case of a patient living 14 months after ventriculomastoid shunt had been performed for tumor of the midbrain with occlusion of the aqueduct of Sylvius In the same year, Dodge, Miller, Lake, and Craig[10] reported a case in which this modification of Nosik's operation was used to relieve obstructive hydrocephalus Their patient had undergone subtotal removal of an astrocytoma of the pons 14 years previously

Matson,[11] in 1953, discussed results of arachnoid-ureterostomy in 50 children Thirty-three of these children were living at the time of his report

Brihaye and Périer,[12] in 1954, discussed the use of ventriculomastoid shunt and its complications in three of their cases Ransohoff,[13] in 1954, described a ventriculopleural anastomosis which he used in six patients

Hakim, Jiménez, and Rosas,[14] in 1955, described a technique of shunting cerebrospinal fluid from the spinal subarachnoid space to the spinal epidural space, and from a ventricle to the spinal epidural space The result of each procedure on a patient was reviewed Jackson and Snodgrass,[15] also in 1955, reviewed their experience with 62 patients studied over a four-year period after lumbar or ventricular peritoneal shunts had been performed

Pudenz, Findlay, Hurd, and Shelden,[16] in 1957, described a technique for shunting cerebrospinal fluid into the right auricle.

AIMS AND OBJECTIVES OF THIS STUDY

No one of the many procedures developed to shunt the cerebrospinal fluid to various parts of the body has been consistently successful. For this reason and because many of the patients are desperately ill and need immediate relief, a simple procedure that can be done under local anesthesia, if necessary, to relieve the increased intracranial pressure was sought. It is the purpose of this presentation to describe and discuss the ventriculomastoid shunt which was performed on 54 patients.

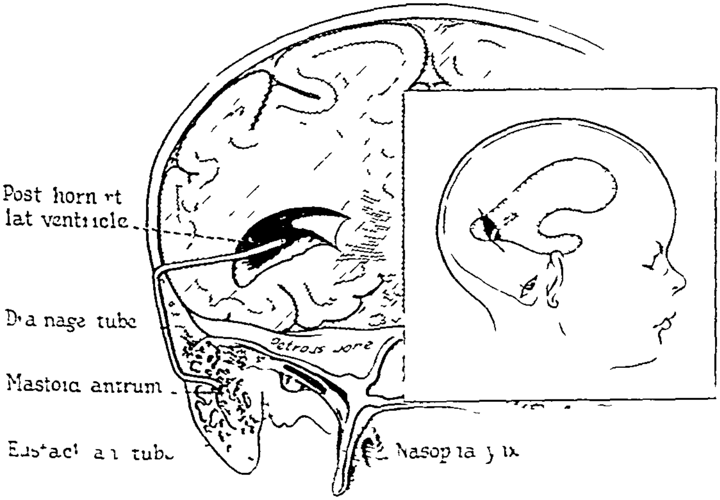

Fig. 1. Diagram of the ventriculomastoid shunt.

TECHNIQUE

The modification of Nosik's operation as described by Svien, Dodge and Lake[9] with some further refinements was used on these 54 patients.

The procedure, as mentioned before, consists of shunting the cerebrospinal fluid from the lateral ventricle via a polythene (polyethylene) tube, one end of which is placed in the lateral ventricle through a burr hole The other end of the tube is passed under the scalp and inserted into the mastoid antrum, after the antrum is opened via a postauricular incision and enough of the mastoid air cells are removed to admit the tube into the antrum A groove is made in the posterior edge of the incision in the bone to help hold the tube in place (see Fig 1)

A further refinement in the technique was employed in these cases It consists of removing the bulk of the mastoid air cells and placing a tantalum button (see Fig 2) in the defect in the mastoid cortex The button is notched along the edge to admit and hold the polythene tube in place The edges of the button may be trimmed to fit into the resultant defect in the bone The soft tissues are sutured in place over the button after meticulous care in controlling all bleeding points This refinement in technique has decreased the number of cases in which granulations have formed in the mastoid and subsequently have plugged the tube

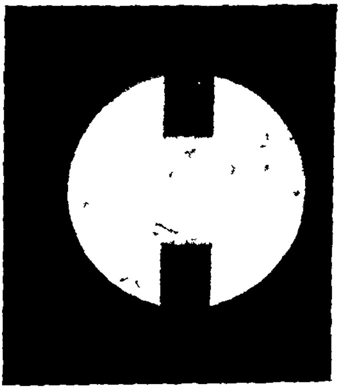

Fig 2 Tantalum Button

This modification of the ventriculomastoid shunt has the advantage of low risk and simplicity It can be carried out under local anesthesia in the critically ill patient Another advantage of this procedure is that the shunt can be explored easily at either the ventricular or mastoid site if cerebrospinal fluid ceases to drain

A simple test that will indicate a functioning ventriculomastoid shunt consists of turning the patient face down and observing cerebrospinal fluid escaping from the nose

TABLE I

Postoperative Follow up and Results of Operation on 18 Patients with Congenital Hydrocephalus

Ages at time of operation 3 weeks to 3¼ years

Case	Result
1	Died 3 months and 3 weeks after operation
2	No follow up
3	Alive 7 months after operation
4	Died 7 days after shunt meningitis
5	Alive 11 months after operation
6	Alive 11 months after operation
7	Died 3 months after operation
8	No follow up
9	Died 3 months after operation
10	Died 17½ months after operation
11	Alive 5 months after operation
12	Alive 6 months after operation
13	Died 4 months after operation
14	Died 8 months after operation
15	Alive 6 months after operation head soft doing well
16	Alive 12 months after operation hydrocephalus had recurred
17	Died 7 months after operation intracranial accident shunt working
18	Died 2 months after operation

Total living—7

CLASSIFICATION OF CASES

The 54 patients considered in this presentation were all those operated on from the initiation of the procedure in 1949 through the year 1955

For study purposes, they have been divided into three groups *1* 18 patients with congenital hydrocephalus, *2* 17 patients with increased intracranial pressure without brain tumor, and *3* 19 patients with increased intracranial pressure with brain tumor

Among the 18 patients with congenital hydrocephalus were six on whom a previous procedure had been done for relief of the hydrocephalus Another patient had been operated on for repair of spina bifida Among the 17 patients with increased intracranial pressure without brain tumor, 14 had had previous operations for relief of the increased intracranial pressure Among the 19 patients with increased intracranial pressure associated with brain tumor, 15 had had previous operations on the brain

The results of the operations and the time of the follow-up are given in Tables I, II and III

TABLE II

Postoperative Follow up and Results of Operation on 17 Patients with Increased Intracranial Pressure without Tumor

Ages at time of operation 17 months to 56 years

Case	Result
19	Died 3 months after operation, improved until death
20	Alive 2 years after operation, tube removed Had meningitis before tube was removed
21	Alive and well 1½ years after operation, tube removed
22	Died 14 months after operation
23	Alive 4 years and 1 month after operation, 2 episodes of meningitis
24	Died 2 years and 1 month after operation
25	Alive 2 years and 1 month after operation, tube removed Teaching school
26	Alive 7 months after operation, doing well
27	Died 1 month after operation
28	Died 2 months after operation
29	Died 2 months after operation
30	Alive 2½ years after operation tube still in place
31	Died 1 year and 1 month after operation
32	Died 2 months after operation
33	Died 5 weeks after operation
34	Alive 2 years after operation, tube removed
35	Died 10 months after operation

Total living—7, tube removed from 4

In the congenital hydrocephalic group, four patients required revision of the shunt, and in one patient the other side was operated upon Of the four revisions, two were done for obstruction at the mastoid end of the shunt by granulation tissue, and the other two were necessary because the tube had slipped out of the mastoid antrum

In the group with increased intracranial pressure without tumor, three patients required revision of the shunt, and in one patient the tube was inserted on the other side The three revisions were done for obstruction from granulations in the mastoid end of the tube

In the group with increased intracranial pressure associated with brain tumor, five patients required revision of their shunts In one instance, the tube had slipped out of the mastoid antrum and, in the other instances, the tube was plugged with clots or granulation tissue

TABLE III

Postoperative Follow up and Results of Operation on 19 Patients with Increased Intracranial Pressure with Intracranial Tumors

Ages at time of operation 2 years to 66 years

Case	Result
36	Died 10 days after operation
37	Died 2½ months after operation
38	Died 1 month and 3 weeks after operation
39	Died 2 months after operation
40	Died 3 months after operation
41	Alive 4 years after operation
42	Died 5 months after operation
43	Died 6 years after operation another operation for brain tumor 2½ years after the shunt
44	Died 7 months after operation
45	Alive Shunt failed after 2 weeks then Torkildsen procedure and Roentgen therapy
46	Lived 2½ years, then died of meningitis Had been rehabilitated
47	Died 1 month after operation
48	Died 6 months after operation
49	Died 2 months after operation
50	Died 8 months after operation
51	Died 2 months and 3 weeks after operation
52	Alive 1 year and 9 months after operation
53	Died 6 weeks after operation
54	Alive 6 years after operation

Total living—3 after ventriculomastoid shunt, 1 after Torkildsen procedure and Roentgen therapy

COMPLICATIONS

Six patients with congenital hydrocephalus had meningitis postoperatively

Among the patients with increased intracranial pressure without brain tumor, three patients had meningitis after operation, interestingly enough, this occurred over a year following the shunt in each instance All recovered In this group also were three patients who had infected cerebrospinal fluid at the time the shunt was established Another patient in this group had bilateral pneumonitis after operation and recovered

Of the patients with increased intracranial pressure associated with brain tumor, four had infected cerebrospinal fluid at the time the shunt was established Two had meningitis after operation and recovered, one of these two had *meningitis three times over a period of years A third patient* died of meningitis two-and-a-half years after operation One patient in this group had pneumonitis and recovered

SUMMARY AND CONCLUSIONS

The literature pertaining to the shunting of cerebrospinal fluid to various parts of the body has been reviewed

The technique of the ventriculomastoid shunt operation employed was a modification of the Nosik procedure This operation was performed on 54 patients, on 18 for congenital hydrocephalus, on 17 for increased intracranial pressure without *brain tumor, and on 19 for increased* intracranial pressure with intracranial tumor

From this study, the following comments may be made

1 A simple procedure has been developed to shunt cerebrospinal fluid from a lateral ventricle to the mastoid antrum

2 The procedure can, if necessary, be done on the desperately ill patient under local anesthesia

3 In some instances, the operation has proved to be a lifesaving procedure and, in a few instances, recovery has permitted removal of the tube

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SIXTH INTERNATIONAL CONGRESS ON DISEASES OF THE CHEST

The Sixth International Congress on Diseases of the Chest will be held at the University of Vienna from August 29 to September 1, 1960

CHANGES IN THE VESTIBULAR LABYRINTH WITH INTENSE SOUND *†‡

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INTRODUCTION

During the course of studies on the effects of intense sound[1,2] on the cochlea of the guinea pig, it became apparent that the vestibular labyrinth was at times also histologically altered. The intensities and durations of the exposures that resulted in marked traumatic injury to the organ of Corti often produced some damage to the nonauditory labyrinth, although not of the extremely severe type described by Kimura and Perlman[3,4] for arterial and venous obstruction. The exposures to intense sound for one to four minutes for this series are of interest for comparison with the recent findings of McCabe and Lawrence[5] who reported collapse of the saccule in 58 per cent of their specimens subjected to a prolonged intense stimulus for 20 minutes. They utilized a random noise of 100 to 10,000 cps and permitted their animals to survive for 56 days, which presents more factors for comparison. Single frequencies were used in our experiments and the post-exposure lives varied from 0 to 133 days.

The selection of suitable material for a study of non-auditory injury proved to be a more arduous task than had previously been anticipated. In the beginning it was necessary to discard all specimens for which artifacts were in evidence in the

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vestibular labyrinth This meant that a large number of preparations were made for the present study and only a few of these could be utilized Rupture of thin membranes is not an uncommon finding in the celloidin embedded and sectioned temporal bones This is true of Reissner's membrane in the cochlea and even more for the membranes of the utricle and saccule An attempt was also made to select the material on the basis of frequency, duration and intensity of the exposures and post-exposure life While we do not feel that all of these variables have been adequately covered, some results, nevertheless, afford an indication of correlation with histological changes The results are, therefore, to be regarded as preliminary for which further experimentation may prove to be of value

MATERIAL

The basis of the present report is the findings for 46 serially sectioned and stained temporal bones of guinea pigs previously exposed to single frequencies varying from 170 to 50,000 cycles per second, and allowed to survive from 0 to 133 days The traumatic stimulus for the 170 and 500 cps exposures was an enclosed acoustic system sealed to the right ear of each animal The traumatic stimulus for the remainder of the frequencies was siren-generated, the only exception being the 13 2 kc exposures for which a transducer employing the principle of the ribbon microphone was used A description of the procedures and cochlear injuries for the latter two types of exposures has been previously reported (Covell and Eldredge[2]) The cochlear injuries for the enclosed system of exposures have likewise been described (Eldredge and Covell[6])

Three different groups of animals were used as controls One was comprised of temporal bone sections from six non-exposed guinea pigs, another was the right temporal bone sections of eight guinea pigs for which the ears had been exposed by the enclosed acoustic system to 500 cps at intensities varying from 118 to 133 db for five to 160 minutes, respectively, and a third group of seven sectioned temporal bones of five young dogs that were siren-exposed to 4 11, and 18 kc for two to four minutes at intensities of 150 to 153 5 db The temporal bone sections of the two ears of a non-exposed dog were also used for the study

All animals were anesthetized with nembutal and perfused with physiological saline solution followed by Heidenhain-Susa fixative, following which the usual procedures for dehydration, embedding in celloidin, sectioning and staining with Harris hematoxylin and eosin were utilized

FINDINGS

The serial sections were examined for changes in the utricle and saccule and their maculas, the semicircular canals and their cristas and the nerve fibers related to these organs Attention was given to a sheet of epithelial-like cells usually consisting of two to four layers which separated the utricle and the semicircular canals from the saccule and the remainder of the vestibule It is considered to be a partition which divides the vestibule into inferior and superior portions It was found to be particularly prominent in the guinea pig, by de Burlet,[7] who first described it in detail It is similar in appearance to the membrana limitans (Waltner) that covers the scala tympani opening of the cochlear aqueduct In the vestibule of the guinea pig's inner ear this partition is continuous with the lining of the vestibule, which is elsewhere a single layer of elongated cells with spindle-shaped nuclei Since there is perilymph on each side of the membrane, its function must be primarily supportive for the utricle as it passes from one bony wall to the opposite side and is reflected onto the vestibular surface of the utricle It also contributes support and attachment for the delicate connective cells in the superior part of the labyrinth We have termed it "membranous partition" and it is referred to as such in this paper

In order to simplify the interpretation of the results the material was divided into nine groups, according to the frequency of each exposure Some of these groups include two different frequencies, which means that the number of specimens exposed to each frequency was too small This was not done, however, when there were any significant differences in the vestibular findings relative to each frequency The post-exposure lives of all animals are not included A rearrangement of the material according to the post-exposure life of each animal proved to disclose interesting findings which are considered later in the analysis of the results

The observations do not include the ruptures of Reissner's membrane because there seemed to be no relation between this finding, which was verified in 17 3 per cent of all specimens, and ruptures in membranes of the vestibular labyrinth On the other hand, marked injury to the organ of Corti, particularly in the basal turn, was more frequently accompanied by changes in the vestibular labyrinth than when marked injury occurred in the apical turns only and/or changes were of a mild nature in the basal turn

Finally, there is brief mention of some degenerative changes in the maculas and detachments of otolithic membranes Changes in the macula of the saccule occurred in approximately 12 per cent of the whole series while that of the utricle presented changes in only two specimens It was felt, however, that they were mild and probably reversible, and that further studies with the use of electron microscopy would be necessary for a definitive evaluation of these degenerative processes The otolithic membranes of both maculas were not consistently altered with any of the exposures Loss of otoliths and detachment occurred in a few instances of the saccular macula but not for the utricular macula The presence or absence of otoliths in these decalcified specimens as compared to similarly prepared unexposed controls was essentially the same

The significant findings for each of the nine groups are given below

Four animals were exposed to a frequency of 170 cps at an intensity of 146 db for one minute There were marked changes in the organ of Corti in all but one of them, but no important changes occurred in the first turn of the cochlea The vestibular changes in this group were very slight, there was a rupture of the membranous partition in only one specimen, and a slight collapse of the saccular membrane in another two to four minutes at intensities of 150 to 153 5 db The temporal bone sections of the two ears of a non-exposed dog were also used for the study

All animals were anesthetized with nembutal and perfused with physiological saline solution followed by Heidenhain-Susa fixative, following which the usual procedures for dehydration, embedding in celloidin, sectioning and staining with Harris hematoxylin and eosin were utilized

FINDINGS

The serial sections were examined for changes in the utricle and saccule and their maculas, the semicircular canals and their cristas and the nerve fibers related to these organs Attention was given to a sheet of epithelial-like cells usually consisting of two to four layers which separated the utricle and the semicircular canals from the saccule and the remainder of the vestibule It is considered to be a partition which divides the vestibule into inferior and superior portions It was found to be particularly prominent in the guinea pig, by de Burlet,[7] who first described it in detail It is similar in appearance to the membrana limitans (Waltner) that covers the scala tympani opening of the cochlear aqueduct In the vestibule of the guinea pig's inner ear this partition is continuous with the lining of the vestibule, which is elsewhere a single layer of elongated cells with spindle-shaped nuclei Since there is perilymph on each side of the membrane, its function must be primarily supportive for the utricle as it passes from one bony wall to the opposite side and is reflected onto the vestibular surface of the utricle It also contributes support and attachment for the delicate connective cells in the superior part of the labyrinth We have termed it "membranous partition" and it is referred to as such in this paper

In order to simplify the interpretation of the results the material was divided into nine groups, according to the frequency of each exposure Some of these groups include two different frequencies, which means that the number of specimens exposed to each frequency was too small This was not done, however, when there were any significant differences in the vestibular findings relative to each frequency The partition was ruptured in four of the five specimens The saccular membrane was collapsed in one and ruptured in another The utricular membrane was also ruptured in one specimen and collapsed in another

Eight specimens were examined from five animals exposed to a frequency of 13 2 kc at an intensity of 140 db for two

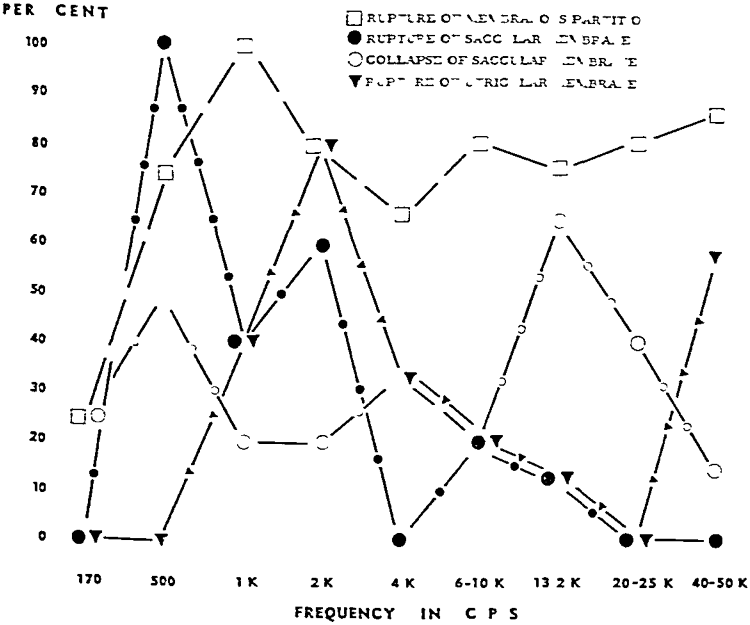

Fig 1 In this chart are shown the percentage values for ruptures of membranes of the vestibular labyrinth as a function of frequency in 46 guinea pig ears exposed to intense sound The results were grouped into nine categories of frequency exposures for reasons stated in the text Clear squares—rupture of the membranous partition solid circles—rupture of the saccular membrane clear circles—collapse of the saccular membrane solid triangles—rupture of the utricular membrane

minutes All of them had degenerative changes in the organ of Corti localized in the first turn, and these extended into the round window region in six specimens Ruptures of the membranous partition were found in six of the specimens and collapse of the saccular membrane in four, one of them was accompanied by rupture In two of the collapsed saccules there were adhesions between the membrane and the macular

Four animals were exposed to 500 cps at an intensity of 142 db for one minute Only one of them had marked lesions in the organ of Corti in the third, second and first turns while the remaining three had similar damage only in second and third turns The membranous partition was found to be ruptured in three of the specimens, and all four had small ruptures in the saccular membrane, accompanied by collapse in two of them

Three animals were exposed to 1 kc at 150 db for one, two and four minutes, and five of their temporal bones were utilized in this study Membranous partition ruptures were found in all five specimens, collapse of the saccular membrane was found in one and ruptures in two The utricular membrane was ruptured in each labyrinth of one animal

Five temporal bones from three animals exposed to 2 kc at 142 db for one, two and four minutes, respectively, were found to present intense changes in the organ of Corti, primarily limited to the second turn of each cochlea Membranous partition ruptures were found in four of the five specimens, and ruptures of the saccular membrane in three, one of them was accompanied by collapse The utricular membrane was ruptured in four specimens

Three animals were exposed to 4 kc at 150, 153 5 and 163 db for two, two and one minutes, respectively All of them had changes in the organ of Corti extending into the first turn, and in one of them there was a rupture of Reissner's membrane in the round window region The membranous partition was ruptured in two of the three specimens and there was collapse of the saccule in one The utricular membrane was collapsed in two specimens, one was also ruptured

Two animals were exposed to the frequencies of 6 kc and three to 10 kc The intensities of the exposures were 142 and 153 5 db for 6 kc and 156, 160 5, and 160 5 for 10 kc The specimens subjected to 142 and 156 db were exposed for four and two minutes, respectively, while all others had one minute exposures All specimens showed degenerative changes in the organ of Corti extending into the first turn, and in two of them into the round window region The membranous

Two animals exposed to 40 kc at 140 and 144 5 db for two and four minutes respectively, and two animals exposed to 50 kc at 142 db for four minutes furnished a total of seven temporal bones The three specimens of the 40 kc exposures presented marked changes in the organ of Corti localized at the round window region Those exposed to 50 kc did not present the same degree of degenerative alterations in the organ of Corti The membranous partition was found to be ruptured in six of the seven specimens, while the saccular membrane was intact in all specimens except one that showed collapse of the anterior end Sloughing of the cells lining the vestibular side of the saccular membrane was found in four specimens, and some nuclei of the remaining cells were pycnotic Displaced and pycnotic nuclei, as well as a deep eosinophilic cytoplasmic stain, were found in the cells of the macula of the saccule in all four specimens of the 50 kc exposures and in one of the three exposed to 40 kc The otolithic

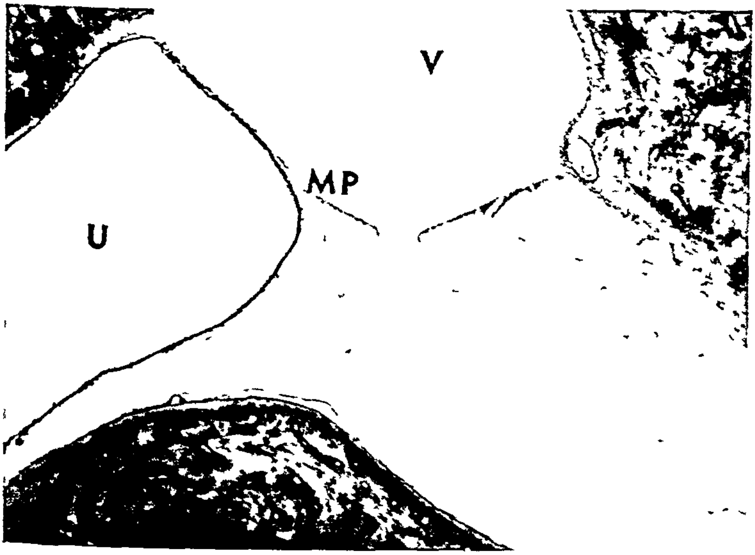

Fig 3 Photomicrograph showing rupture of the membranous partition in the ear of a guinea pig that was exposed to 13 2 kc at 140 db for two minutes and allowed to live for 133 days The only other finding of significance was a collapse of the saccule that was not unusual in animals with prolonged post exposure lives MP—membranous partition U—utricle V—vestibule (X55)

epithelium The utricular membrane was collapsed in one specimen and ruptured in two others One of the ruptures, however, had been repaired by connective tissue (see Fig 5)

Five animals were exposed to the frequencies of 20 kc (one specimen) and 25 kc (four specimens), respectively, the intensities varied from 147 to 152 db for one to four minutes With the exception of the specimen exposed to 20 kc, which had marked changes in the organ of Corti localized in the first turn, all others had intense degenerative lesions in the round window area The membranous partition was ruptured in four specimens The saccular membrane was intact in three, there being collapse in the other two, one of them with adhesion formation In this group there were no changes in the utricular membrane On the other hand one of the specimens showed the presence of leucocytes in the perilymphatic space of the posterior canal in the region of the ampulla

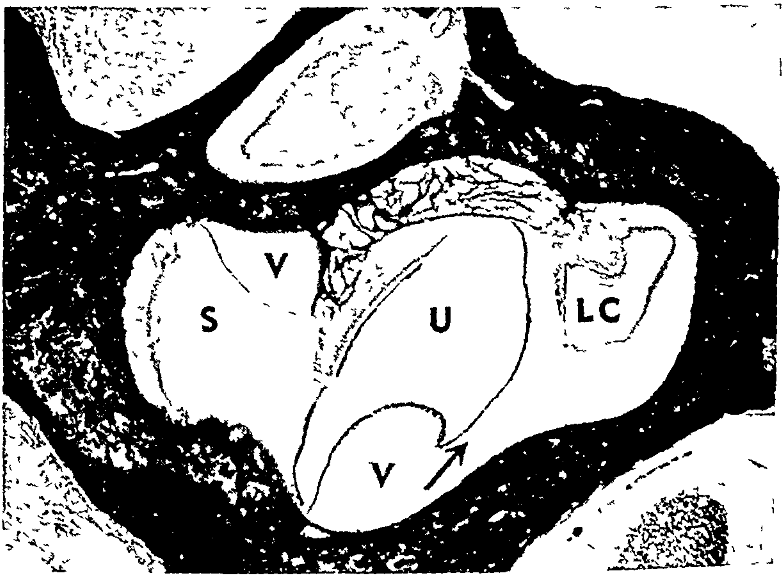

Fig 2 Photomicrograph of a section through the vestibular labyrinth of a guinea pig showing the relations between the saccule, utricle and lateral canal This animal was exposed to 6 kc at 142 db for 4 minutes and sacrificed eight days later The only finding of any significance was a rupture of the membranous partition that is indicated by the arrow LC—lateral canal, S—saccule U—utricle V—vestibule (X25)

ruptures of the saccule The triangles represent the ruptures of the utricular membrane Collapse of the utricle is not shown because it is a less common finding and probably related to rupture of the membranous partition

Rupture of the membranous partition (see Figs 2, 3) varied from 70 to 100 per cent for all specimens exposed to frequencies of 500 cps or above Only 25 per cent of the 170 cps exposures revealed rupture of this partition

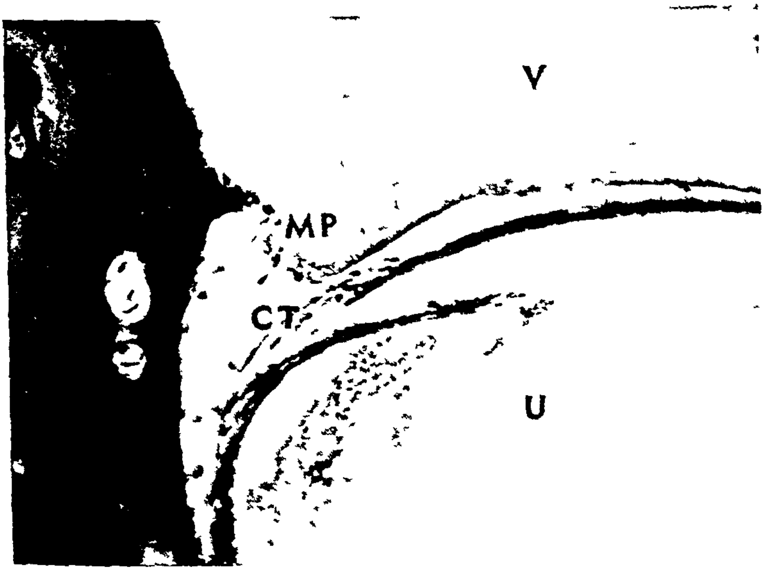

Fig 5 Photomicrograph of a section through a ruptured utricular membrane of a guinea pig's ear exposed to 13 2 kc at 140 db for two minutes The animal was allowed to survive for 133 days There is an attempt on the part of the connective tissue to repair the rupture The membranous partition is also ruptured and certain of its cells are in a degenerative state CT—connective tissue MP—membranous partition U—utricle V—vestibule (X220)

Rupture of the saccular membrane occurred in all 500 cps exposures and became less with the increase in frequency Collapse of the saccule (see Fig 6) was not always accompanied by rupture and occurred chiefly for frequencies of 6 kc or more, where it became more common than rupture

Rupture of the utricular membrane (see Figs 4, 5) occurred at frequencies of 1 kc or above, and was present in 80 per membrane was detached, particularly at the anterior end, in three specimens and otoliths were found free in the saccule and attached to the saccular membrane The utricular membrane was ruptured in four specimens, one of which presented two ruptures occurring in different places Collapse was found in only one specimen In three specimens hemorrhage and edema with leucocytic response were found in the tissue

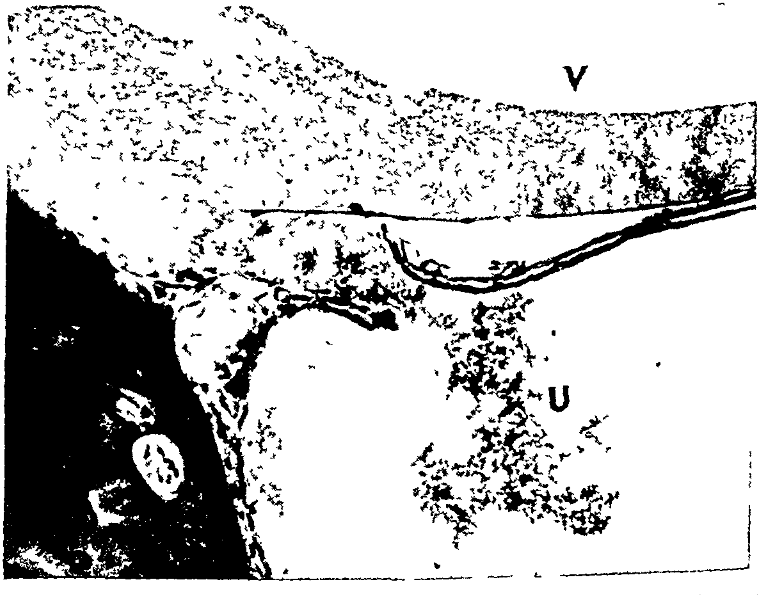

Fig 4 Photomicrograph of a section through the ruptured portion of a utricular membrane in a guinea pig s ear that had been exposed to 2 kc at 142 db for two minutes The post exposure life was six days This area in the inferior and medial wall of the utricle was found to be the commonest point of utricular rupture U—utricle V—vestibule (X220)

and around the nerve fibers from the macula of the utricle (see Fig 7) The latter presented a normal appearance in all specimens except in one for which a few nuclei were pycnotic The otolithic membrane of the macula of the utricle was without changes

Fig 1 summarizes the results obtained for each of the nine groups The squares show the percentages of rupture of the membranous partition Collapse of the saccular membrane is represented by clear circles, and solid circles represent specimens These controls were particularly valuable in ascertaining some minor changes due to technical procedures such as occur in the otolithic membranes

A group of eight guinea pigs, for which the right ears had been exposed to 500 cps was also used in a control study to compare the effects of lower intensities and longer durations of exposure Four of these had been exposed at 118 db for 160 minutes, two were exposed at 128 db for 20 minutes, and two at 133 db for five minutes All eight animals were sacrificed on the same day as the exposures None of these except the latter two showed marked cochlear damage and rupture of Reissner's membrane The latter was collapsed over the organ of Corti in several of the 160 minute exposures The membranous partition of the vestibule was

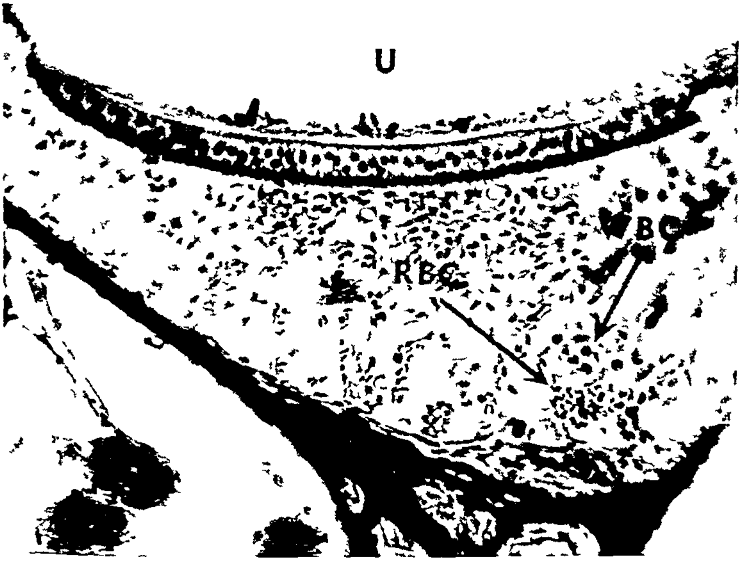

Fig 7 Photomicrograph of a section through the macula of the utricle of a guinea pig s ear that was exposed to 50 kc at 142 db for four minutes The post exposure life was two days There is evidence of hemorrhage and leucocytic response in the loose connective tissue and between the nerve fibers at the base of the macula This specimen also revealed rupture of the membranous partition collapse of the utricular membrane in its inferior portion and sloughing of cells of the vestibular lining as well as those in the outermost layer of the saccular membrane RBC—erythrocytes U—utricle WBC—leucocytes (X220)

cent of the 2 kc exposures and 30 and 40 per cent of the 4 kc exposures, respectively At higher frequencies of 6 to 25 kc it was found in a small number of specimens, but again became significant for the 40 and 50 kc group for which there was 57 1 per cent ruptures

CONTROL GROUPS

Serial sections through the vestibular labyrinths of a series of temporal bones of six non-exposed guinea pigs served as controls They were of the same source and ages as the exposed animals used for this study The fixation, embedding, sectioning and staining were identical to the procedures used for the preparation of the temporal bones from guinea pigs exposed to intense sound None of the changes described for the inner ears of the exposed guinea pigs appeared in these

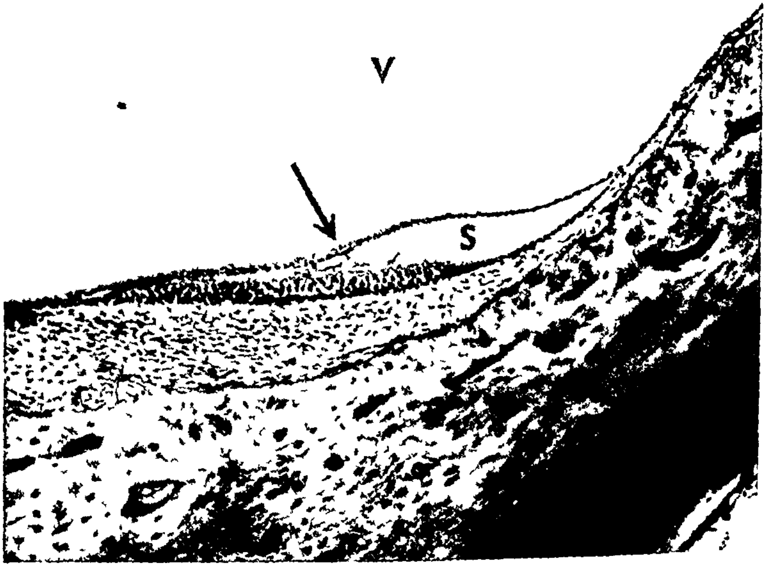

Fig 6 Photomicrograph of a collapsed saccular membrane in the right ear of a guinea pig exposed to 500 cps at 140 db for one minute and sacrificed 14 days later The membrane of the saccule was found to be ruptured at another level than illustrated There is some tendency for adhesions (indicated by arrow) to form between the collapsed membrane and the cells of the macula The latter reveal only slight degenerative changes, many of which are probably of a reversible type S—saccule, V—vestibule (X115)

changes that could be related with length of survival time of the animals This agreed with the finding that there was no evidence of proliferation of the cells lining the vestibule in an attempt to repair these ruptures

The next structure most commonly involved was the saccule Rupture of the saccular membrane occurred in approximately one-fourth of the specimens, while collapse was found in one-third There was a tendency for rupture to be more common to exposures of 500 to 2000 cps (inclusive) and for collapse to be more frequent than ruptures for exposures of 4 kc and above Rupture of the saccule did not appear to change with post-exposure life, which agreed with the lack of evidence of repair activity. Collapse, on the other hand, was much more common for the specimens with long lengths of survival time From 0 to 2 days, 18 1 per cent of 11 animals showed collapse of the saccule, while 37 5 per cent of eight specimens showed collapse at 14 to 36 days The percentage was increased to 71 4 per cent for seven specimens that were allowed to survive from 63 to 133 days

Rupture of the utricular membrane occurred in approximately one-third of all specimens The most frequent point of rupture was found to be below and medial to the macula in the vicinity of the utricular duct It was more common for exposures of 1 to 4 kc and for the 40 and 50 kc exposures There was a definite tendency for it to become less frequent with the increase in post-exposure life This is probably due to repair of the rupture by connective tissue cells that proliferate from the connective tissue layer of the utricular membrane Collapse of the utricular membrane was a less common finding, being present in approximately 15 per cent of the whole series It did not show any relation to length of post-exposure life and was not found in specimens with intact membranous partitions

The evidence for damage to the sensory and supporting cells of the macula was slight or even lacking in most preparations The sensory cells for most of the 40 or 50 kc exposures and for a few other specimens revealed displaced and pycnotic nuclei and the cytoplasm of the cells stained deeply with eosin The inferior portion of the macula of the utricle showed found to be ruptured in six of the eight specimens, the saccular membrane was ruptured in one, but varying degrees of collapse of the saccule was apparent in five specimens There was no rupture of the utricular membrane in any specimen, but there was evidence of partial collapse in four specimens

Serial sections through seven temporal bones of five young siren exposed dogs[1,2] were examined for comparison of findings with those of the guinea pigs Two of the dogs had been exposed to 4 kc at 153 5 db for two and four minutes, one had been exposed to 11 kc at 153 5 db for four minutes and two had been exposed to 18 kc at 150 db for two and four minutes The post-exposure lives varied from 0 to 13 days There was severe injury to the organ of Corti in all specimens, with rupture of Reissner's membrane in four of the seven The membranous partition of the vestibule was ruptured in five The saccular membrane was ruptured in four specimens with the presence of a few red blood cells in the saccule in two specimens There was no apparent collapse of the saccule in any of the specimens The utricular membrane was ruptured in two and markedly collapsed in a third Slight changes in the sensory and supporting cells of the macula of the saccule were in evidence in three specimens but none were apparent in the macula of the utricle There were no apparent changes in the inner ears of the non-exposed dog used to control this study

REVIEW OF FINDINGS

The most common alteration in the vestibular labyrinth as a result of sound stimulus traumatic to the organ of Corti was found to be the rupture of the membranous partition that separates the vestibule into superior and inferior parts It is doubtful that rupture of this membrane is of much, if any, functional significance unless it can result in extensive collapse of the utricle, a finding which was not encountered for any of the exposures The inferior part of the utricle beneath the macula was in some specimens collapsed as a result of loss of the support of the membranous partition The significance of such a finding is debatable The percentage of the membranous partition ruptures showed no appreciable changes that could be related with length of survival time of the animals This agreed with the finding that there was no evidence of proliferation of the cells lining the vestibule in an attempt to repair these ruptures

The next structure most commonly involved was the saccule Rupture of the saccular membrane occurred in approximately one-fourth of the specimens, while collapse was found in one-third There was a tendency for rupture to be more common to exposures of 500 to 2000 cps (inclusive) and for collapse to be more frequent than ruptures for exposures of 4 kc. and above Rupture of the saccule did not appear to change with post-exposure life, which agreed with the lack of evidence of repair activity Collapse, on the other hand, was much more common for the specimens with long lengths of survival time From 0 to 2 days, 18 1 per cent of 11 animals showed collapse of the saccule, while 37 5 per cent of eight specimens showed collapse at 14 to 36 days The percentage was increased to 71 4 per cent for seven specimens that were allowed to survive from 63 to 133 days

Rupture of the utricular membrane occurred in approximately one-third of all specimens The most frequent point of rupture was found to be below and medial to the macula in the vicinity of the utricular duct It was more common for exposures of 1 to 4 kc and for the 40 and 50 kc exposures There was a definite tendency for it to become less frequent with the increase in post-exposure life This is probably due to repair of the rupture by connective tissue cells that proliferate from the connective tissue layer of the utricular membrane Collapse of the utricular membrane was a less common finding, being present in approximately 15 per cent of the whole series It did not show any relation to length of post-exposure life and was not found in specimens with intact membranous partitions

The evidence for damage to the sensory and supporting cells of the macula was slight or even lacking in most preparations The sensory cells for most of the 40 or 50 kc exposures and for a few other specimens revealed displaced and pycnotic nuclei and the cytoplasm of the cells stained deeply with eosin The inferior portion of the macula of the utricle showed similar changes Except for these there were no definite cytological changes in the utricular macula for any of the exposures. Loss of otoliths occurred in the saccular macula in several specimens, mainly in the 40 and 50 kc exposures, and in some of these many otoliths appeared free in the saccule Similar changes were not seen in the utricular macula

Hemorrhage with leucocytic reaction and edema about the nerve fibers at the base of the macula of the utricle were found in two specimens exposed to 40 and 50 kc, respectively Leucocytes appeared in the perilymphatic spaces of the semicircular canals and the utricle in two other specimens One had been exposed to 13 2 kc and the other to 25 kc

In the specimens exposed to high frequencies of 40 and 50 kc there was evidence of sloughing of cells of the vestibular surface of the saccular membrane, and some of the remaining nuclei were pycnotic Similar findings were found for the utricular membrane although they were not so pronounced

CONCLUSIONS

1 Severe traumatic injury to the organ of Corti, caused by intense sound, particularly in the basal turn, is frequently accompanied by damage to membranes of the vestibular labyrinth

2 The most common alteration in the vestibular labyrinth produced by instense sound is rupture of the "membranous partition"

3 The wall of the saccule was ruptured in approximately one-fourth of the specimens and collapsed in about one-third Rupture was of highest incidence for exposures of 500 to 2000 cps and collapse was more in evidence for exposures of 4000 cps and above The latter was also increased with prolonged post-exposure life

4 The utricle was ruptured in approximately one-third and the inferior portion of it collapsed in about one-sixth of all specimens Rupture was more common in 1 to 4 kc and 40 and 50 kc exposures It was less frequent in specimens with prolonged post-exposure lives, presumably because of the tendency for repair

5 The sensory and supporting cells of the macula of the saccule revealed only a few changes of mild nature Similar cells of the macula of the utricle were usually not altered

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XII INTERNATIONAL CONGRESS OF LOGOPEDICS AND PHONIATRICS

For the XII International Congress of Logopedics and Phoniatrics, Dr Perelló has been in charge of the Rapport on "Functional Dysphonia," therefore, he requests every colleague to have something published about this matter and kindly send him a reprint for the record of said Rapport

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THE ROLE OF THE VOCAL CORDS IN HUMAN RESPIRATION

Observations on Respiratory Function in the Human with Paralyzed Vocal Cords and Totally Absent Vocal Cords*

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I A REVIEW OF ALL PREVIOUS WORK AND LITERATURE ON THE PHYSIOLOGIC RESPIRATORY MECHANISM OF THE VOCAL CORDS A PRESENTATION OF THE FOUR MAJOR CONCEPTS OF THE VOCAL CORDS IN RESPIRATION GAINED FROM THIS REVIEW

The respiratory function of the larynx by the valvular action of the vocal cords has in the past been the subject of extensive investigative studies in animal and cadaveric experiments Early studies by Longet,[19] Wyllie,[39] Brunton and Cash,[2] Semon,[34] Semon and Horsley,[36] were in agreement as to the valvular function of the cords of the larynx Recent studies by Fink, Basek and Epanchin[11] and Feinstein,[8] employing photographic, roentgenologic, and electromyelographic techniques have offered additional confirmatory evidence of this function

As far as we have been able to find, although Dionisio[6] reported dynamometric measurements for the pressure within the larynx of experimental animals, and Neumayer[22] reported manometric studies on the pressures within the human larynx, neither made graphic records Hooper,[14] working with Professor Bowditch at Harvard, was one of the first to secure graphic records of the movements of the laryngeal cartilages on stimulation of the external branch of the superior laryngeal nerve Murtaugh[21] obtained some excellent graphic records of abduction and adduction of the cords of the larynx

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of a cat and goat, and Feinstein,[8] employing electromyography, recorded changes in the human larynx Fink, Basek, and Epanchin[10] obtained additional changes in the human by employing electromyography In the information available, the graphic data obtained pertained only to changes within the larynx itself, and represented no particular influence of the larynx on respiratory ventilation

After much consideration of a method that would provide graphic material for interpretation of the effect of the valvular cord action of the larynx on respiration, the utilization of accepted standardized pulmonary function tests seemed to afford an ideal laboratory method for conducting a scientific evaluation of the previously held concepts and theories on the effect of the vocal cords on respiratory ventilation

To secure a completely accurate idea of previously and currently held concepts regarding the effect of this sphincteric valvular cordal effect on respiration, it was necessary to carry out a thorough review of the literature limited to this particular subject to provide the major concepts which could be subject to an accepted laboratory study, and to provide graphic material of the results for interpretation

A great portion of this review revealed that the majority of previous investigative work had been confined to the larynx itself For example, in 1841 Longet[19] reported his research on the function of the muscles and nerves of the larynx, emphasizing its valvular function In 1866, Wyllie[37] reported similar findings in his observations on the physiology of the larynx In 1882, Brunton and Cash[2] presented their study on the valvular action of the larynx, and in 1883, Hooper[15] showed the results of his experiments on the tension of the vocal bands In 1890, he further reported his methods of demonstrating laryngeal movements In the same year, Semon[35] reported on the position of the vocal cords in quiet respiration in man, and together with Horsley,[36] contributed a report on the experimental investigation of the central motor innervation of the larynx In 1892, Dionisio[6] reported the dynamometric measurements of the pressure within the larynx of experimental animals, and in 1910, Neumayer[25] reported the pressures in the human larynx Between 1902 and

1951, Onodi[27] established the principles of laryngeal innervation which were confirmed by Lahey,[17] Nordlund,[24] Ziegelman,[40] Lemere,[18] Terracol,[38] Furstenberg,[12] Murtaugh,[21] and Feinstein[7] In 1929 and 1949, Negus[22,23] in his monumental studies on the larynx, reported the effects of the laryngeal vocal cords on respiration In 1944, Pressman[29] reported further on the effects of the sphincteric action of the larynx on intra-abdominal pressure and on the muscular action of the pectoral girdle In January, 1956, Fink, Basek and Epanchin[11] reported the laryngeal muscular activity in respiration by electromyography and X-ray studies

It seems that the excellent work of the above investigators on the larynx resulted in an evolution of concepts regarding its effect on respiration Negus[22,23] first stressed the importance of looking beyond the larynx in respiratory studies, for he feared that the very presence of the larynx may act as a hindrance by causing narrowing and obstruction to the air current This search led to a study of the size of the glottis itself, the caliber of the tracheo-bronchial tree, the depth and rate of respiration, vital capcity, the size of the lungs, and the elimination of friction by the adaptability of the larynx

Pressman,[29] in addition to making significant contributions on the effects of the sphincteric action of the larynx on intra-abdominal pressure and on muscular action of the pectoral girdle, has presented an excellent compendium of all the work of the previous investigators as it pertains to the role of the vocal cords on respiration

The studies of Brunton and Cash,[2] Semon,[35] Negus,[22,23] Jackson,[16] and Pressman[29] postulate that the vocal cord action increases intra-thoracic and intra-abdominal pressure by trapping air within the tracheobronchial tree In respiratory physiology this is important, primarily in circulatory changes and in cough Negus[22,23] and Pressman[29] state that experimentally, when this valvular function is not functioning, there is about 20 per cent loss in ability to raise intra-abdominal pressure and a corresponding escape of air not under pressure

Negus,[22,23] Jackson,[16] Rahn[30] and Riley,[32] in regard to the role of the cords in producing a physiologic narrowing of the glottic chink, which supposedly effects an interchange of gases between the pulmonary alveoli and the blood stream, concur that oxygen passes through the alveoli walls into the blood stream, not during inspiration, but in expiration, with thoracic contraction, and that the rapidly increased intra-pulmonary pressure acting on the increased resistance of the partially adducted cords further increases the alveolar oxygen pressure and the speed of its passage into the blood stream

Gordon,[13] Mills,[20] and Rahn,[31] in regard to vital capacity, agree that while it depends partly on the size and structure of the lungs, the rate of respiration is determined by the caliber of the air passages which cannot convey air at more than a certain speed The ultimate efficiency of respiratory exchange should depend, therefore, upon the relationship of the glottic aperture to that of the trachea, as brought out by Negus[22 23] suggesting the tremendous importance of glottic action on respiratory physiology and its relationship to partial or complete opening and closing in the exclusion or retention of air The movements of glottic dilatation at the beginning of inspiration and partial closure during expiration, both at times of exertion and during quiet respiration are thus explained

As brought out by Bateman,[1] Fowler,[11] Pressman,[29] and Rahn,[30] in man, with the finely divided air spaces and large volumes of supplemental and residual air, there is actually no need for any immediate retention of air by glottic action for effective function If the glottis is partially closed at the beginning of expiration, bronchial musculature may force some of the air backward into the distant alveoli, assisting the process of diffusion If obstructed on inspiration, bronchial dilatation will abstract air from the alveoli to mix with the in-rushing uncontaminated tidal air

Negus[22 23] maintains a regulatory function for the cords in ventilation By its obstructive action the glottis can retard the filling or emptying of the bronchi, and thus delay the Hering-Breuer reflex, which provides time for the adequate exchange of gasses in the lungs This keeps the O_2 and CO_2 contents of the blood at the right level It is the complete dilatation of the bronchi at the end of inspiration which sends a reflex stimulus to the respiratory center through the afferent vagal fibers, this stimulus initiates expiration. The reverse effect occurs at the end of expiration, when the bronchi are contracted.

Numerous investigators, including Dean,[7] Fenn,[8] Haldane,[11] Otis,[28] and Pressman,[29] have felt that glottic obstruction to the entry of air during inspiration adds to the reduction of intra-pulmonary and intra-thoracic pressure. This produces pressure on the great veins and the right auricle, and sucks blood back into the heart during inspiration. Descent of the diaphragm at the same time squeezes blood from the splanchnic area into the vena cava, and thus to the right auricle. It causes dilatation of the pulmonary capillaries and facilitates the flow of blood through the lungs, thus providing a large volume of blood deficient in oxygen and overcharged with CO_2 to meet the newly entering tidal air which fills the dilating alveoli. The rush of blood through the lung delivers a copious supply to the left side of the heart, and according to the law of the heart, the left ventricle, therefore, contracts more forcefully and raises the aortic and general arterial pressure, in expiration, the reverse is true. Obstruction throws back pressure on the venous circulation, slowing it at a time when the emptying of the lungs does not allow for active respiratory exchanges. The pulmonary capillaries are compressed in unison, with the partial collapse of the alveoli. There is, however, a temporary rise of aortic pressure at the beginning of expiration, since compression of the lungs by the expiratory effort squeezes blood into the left side of the heart.

Negus[22,23] has ascribed two additional functions to the vocal cords in respiration *1* the main regulating valve supplying the fine adjustments in augmenting the obstructive action, correlating the volume of blood and its rate of passage through the lungs with the volume of air in the alveoli, especially to its contents of oxygen and carbon dioxide, *2* adapting the size of the lumen of the airway to the needs of the moment.

The vocal cords represent a point of constriction in the lower respiratory tract which is variable in degree, depending upon the position of abduction or adduction assumed by the cords. In inspiration, as in singing, Pressman[29] has shown that the cords are so abducted they can scarcely be distinguished from the lateral walls of the larynx; in expiration, there is marked narrowing of the glottic chink. Pressman concludes, therefore, that in each respiratory cycle there is a to-and-fro movement which is naturally more conspicuous with deep breathing than with shallow breathing at rest. The marked degree of approximation on expiration establishes a point of relative resistance to the escape of air with a momentary increase of intra-tracheal, intra-bronchial, and intra-alveolar pressures. This elevated pressure increases the oxygen flow from the alveoli through the alveolar walls into the blood stream. The vocal cord action rapidly increases the pressure to insure rapid absorption of large quantities of oxygen. In addition to these purposeful movements of the vocal cords, there is a lowering, backward displacement and lateral deviation to the left of the entire larynx. These movements are due to intra-thoracic pressure variations, are of small amplitude, and are not universally present.

This review of all previous work and literature reveals that four major respiratory functions of the vocal cords have been ascribed:

1. Regulation of gaseous transport across the alveolar membrane by increasing intra-thoracic pressure during expiration.

2. Regulation of alveolar filling by forced passage of gas into unaerated segments of the lungs on expiration.

3. Regulation of cardiac output by effecting a rise in pulmonary pressure with decreasing venous return during expiration.

4. Control of the mass motion of gas during ventilation with the cords imposing a time element to expiration.

II. RE-STATEMENT, ANALYSIS, AND DISCUSSION OF FOUR CONCEPTS OF VOCAL CORD ACTION IN RESPIRATION GAINED FROM REVIEW OF LITERATURE

Statement of Aims and Objectives of Present Study. Methods

Employed in Study Brief Clinical Resume of Subjects Used Brief Description of Tests Used Discussion of Results

From this historical review it is apparent that the role of the vocal cords in respiratory function has been long accepted A number of theories have been advanced, each describing various mechanisms by which the vocal cords control or regulate some phase of respiration, however, experimental work to support these findings has for the most part been confined to studies of the larynx itself, and is inadequate Much of this experimental data has been obtained from lower animals, and is of questionable validity when applied to the human Although a wealth of data dealing with respiratory function has been accumulated in recent years, little or no attempt has been made to analyze the role of the vocal cords in the complex mechanism of respiration, so that the accepted theories have remained unquestioned Recent interest and activity in surgery of the larynx, trachea, and thyroid have prompted intensive anatomic, neurological, roentgenological, and electromyographic studies of the cords in phonation, however, their time honored role in respiration has been unchallenged, obscure and explainable only by primitive concepts

It is apparent that all of the four major respiratory functions of the vocal cords revealed by a review of literature are fundamentally similar, in that they place the vocal cords as the regulator of respiration in the expiratory phase, and that each theory deals with the effects of elevated expiratory pressure on some phase of ventilation or gas exchange

The first theory, *i e*, the regulation of gaseous transport across the alveolar membrane by increasing intra-thoracic pressure during expiration, was first proposed by Negus,[22 23] and supposes that with cord adduction in expiration the rise in intra-pulmonary pressure effectively elevates the partial pressure of oxygen and thus increases oxygen transport across the alveolar membrane Although this concept of expiratory predominance in gas exchange seems logical and actually occurs in some lower vertebrates, it is not quantitatively significant in the human, as reference to the Oxygen Dissociation Curve discloses[1]

The second theory, *i.e.*, the regulation of alveolar filling by forced passage of gas into unaerated segments of the lung during expiration, states that the rise in expiratory pressure effected by the cords forces inspired gas into alveoli non-aerated. This concept is no longer tenable in light of the recent work of Roos, Murphy, and Dahlstrom[33] that ventilation is not enhanced by increase of intra-pulmonary pressure.

The third theory, *i.e.* the regulation of cardiac output, by effecting a rise in pulmonary pressure with decreasing venous return, supposes that the diminished venous return attendant to expiration is the result of cord adduction with a rise in pulmonary pressure. While this is true in the classic Valsalva maneuver, it is not the case in basal respiration, where the increase in intra-pulmonary pressure is directly related to the elastic recoil of the lung which occurs with the end of inspiration.

The final theory, *i.e.* the control of the mass motion of gas during ventilation with the cords imposing a time element to expiration, concerns the role of the vocal cords in minute to minute regulation of expiration, and its effect on expiration time rather than pressure. Although this theory has no experimental background, it is in keeping with modern physiologic concepts of the effect of time as an adjunct to intra-pulmonary mixing with the end-result the creation of homogenous substrate to promote even trans-alveolar exchange of oxygen and carbon dioxide.

In view of the sparse or inadequate experimental work to support any of these theories in human respiration, it seemed logical to reevaluate the role of the vocal cords in respiration. To this end the application of the modern respiratory function tests appeared admirably suited. It was the aim and objective of this study to take two groups of subjects representing the extremes in vocal cord abnormalities, and subject them to the entire battery of respiratory function studies, including ventilation and mixing analysis.

The first group of subjects studied had various types of unilateral and bilateral cord paralysis presenting marked narrowing of the laryngeal aperture. In this group were two women and three men in good general health, with normal chest X-rays, and laryngoscopic evidence of vocal cord paralysis In one woman bilateral cord paralysis followed a thyroidectomy The other woman's unilateral cord paralysis was spontaneous for which careful laryngological, medical, and neurological work-up failed to determine the etiology The three men had unilateral cord paralysis following radical neck dissection for carcinoma

The second group studied were subjects without vocal cords as the result of total laryngectomy for carcinoma of the larynx They were all white males in good general health with normal chest X-rays and were free of any evidence of carcinoma

The subjects of both Group I and Group II were free of any evidence of unrelated cardio-respiratory disease or subjective signs of respiratory deficiency

While the various techniques for evaluating pulmonary function have individual limitations, when combined, these tests offer an accurate index of the subject's ability to move adequate volumes of gas in and out of the lungs within a specified time, and an evaluation of the intra-pulmonary mixing of the inspired and residual gases of the lung

The test battery utilized in this study was arranged into two groups the first comprised the following pulmonary function tests which were classic for evaluating accurately ventilatory mechanics with an assay of respiration in all phases, time, and maximum effort

Tidal volume, defined as the volume of gas the patient is breathing quietly and at rest

Minute volume, defined as the volume of air entering and leaving the lungs per breath per minute

Functional residual capacity, defined as the volume of gas remaining in the lungs after a natural expiration

Vital capacity, defined as the volume of gas that can be expelled by a maximal expiration following a maximal inspiration

Exploratory reserve volume, defined as the volume of gas remaining in the lungs after a maximal expiration.

Maximal breathing capacity, defined as the maximal volume of gas that can be breathed per unit time

End tidal CO_2 determination, defined as the pressure in mm of CO_2 gas in last portion of expiration

Inspiratory capacity, defined as the maximal volume of air that can be inspired from the end of a normal expiration

Timed vital capacity, defined as the performance of vital capacity in relation to time

Total lung capacity, defined as the sum of vital capacity and residual capacity

Residual volume, defined as the volume of gas remaining in the lungs after a maximal expiration

The second group of pulmonary function studies were used to analyze the functional effects of ventilation, including the evenness of gaseous mixing and the elasticity of the tracheobronchial tree and the parenchyma

Fowler's single breath test, defined as the method of determining the evenness of ventilation

Nitrogen equilibration, defined as the method of determining the functional residual volume of the respiratory system The time required is analagous to the seven-minute Cournand Washout Test, and measures the evenness of ventilation when the dead space and ventilation pattern are normal

The elastance and resistance were studied by recording the maximal expiratory and inspiratory pressures by sinusoidal wave, by outflow curves, and by maximal flow velocities

All testing was carried out under basal conditions with the norms for age, height, and weight drawn from the standard table of Cournand and Richard, Comroe, et al[4]

The results of this study show gross abnormalities in some phase of testing in both groups In Group I, all subjects had low maximal breathing capacities with the exception of one, who was borderline normal In Group II, all subjects had low maximal breathing capacities and additionally had abnormalities in mixing, as shown in the Fowler single breath tests, there was one possible exception to this

In Group I the deficit in the maximal breathing capacity was observed to accompany a rise in the functional residual capacity to the upper limits of normal These findings are similar to those patients studied elsewhere with clinical emphysema of the acquired or senile type It seems apparent that the expiratory obstruction attendant to cord paralysis results in a loss of timed breathing capacity with eventual loss of pulmonary elastance and rise in residual volumes The one exception to this is the subject who was the borderline limit of normal

In Group II all subjects had lowered maximal breathing capacities, and with one exception impaired intra-pulmonary mixing as shown in the Fowler single breath tests It is of special interest that the loss of pulmonary elastance is not a component here as in Group I, but rather demonstrates the deficit in effective time and mass gas motion and mixing attendant to the absence of vocal cords

SUMMARY AND CONCLUSIONS

We have presented a review of all previous work and literature on the physiologic mechanism of the sphincteric vocal cord action in respiration From the historical review, four major concepts of cord function were presented, summarized and discussed In the absence of adequate experimental work to support these theories in the human, and with newer methods of accepted respiratory study now available, it was felt that re-evaluation of these theories would be in order To accomplish this, two groups of subjects representing the extremes in vocal cord abnormality were subjected to the entire battery of respiratory function studies To our knowledge this study represents the initial application of the pulmonary function tests to an evaluation of vocal cord action in human respiration

From our review of the literature on the sphincteric action of the vocal cords on respiration, and a careful study of the results of pulmonary function tests carried out in subjects with the extremes in vocal cord abnormalities, we can conclude

1 That the gaseous transport across the alveolar membrane by an increase of intra-thoracic pressure produced by the cords in expiration is quantitatively insignificant in the human

2 That ventilation in the human is not enhanced by an increase of intra-pulmonary pressure produced by the cords in expiration

3 That cardiac output is not affected by cord adduction in expiration with the basal respiratory conditions prevailing in the human where the increase in intra-pulmonary pressure is directly related to the elastic recoil of the lung which occurs with the end of inspiration

4 That laryngeal paralysis in the human results in a definite decrease in maximal breathing capacity in the majority of subjects studied with a rise in the functional residual capacity to the upper limits of normal

5 That laryngeal paralysis in the human produces a loss of breathing capacity (timed) with eventual loss of pulmonary elasticity and rise in residual volumes

6 That in the majority of subjects studied, total vocal cord absence in the human results in lowered maximal breathing capacities and impaired intra-pulmonary mixing

7 That total vocal cord absence has less effect on pulmonary elastance than cord paralysis

8 That total cord absence creates a significant deficit in time and mass gas motion and mixing

9 That both cord paralysis and total cord absence is not a physiological innocuous occurrence, even in subjects clinically free of symptoms of respiratory deficit

10 Finally, that the absence of normal vocal cord function, one, who was borderline normal In Group II, all subjects had low maximal breathing capacities and additionally had abnormalities in mixing, as shown in the Fowler single breath tests, there was one possible exception to this

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4 That laryngeal paralysis in the human results in a definite decrease in maximal breathing capacity in the majority of subjects studied with a rise in the functional residual capacity to the upper limits of normal

5 That laryngeal paralysis in the human produces a loss of breathing capacity (timed) with eventual loss of pulmonary elasticity and rise in residual volumes

6 That in the majority of subjects studied, total vocal cord absence in the human results in lowered maximal breathing capacities and impaired intra-pulmonary mixing

7 That total vocal cord absence has less effect on pulmonary elastance than cord paralysis

8 That total cord absence creates a significant deficit in time and mass gas motion and mixing

9 That both cord paralysis and total cord absence is not a physiological innocuous occurrence, even in subjects clinically free of symptoms of respiratory deficit

10 Finally, that the absence of normal vocal cord function, either from paralysis or laryngectomy, results in a definite measurable physiologic deficit in respiratory function

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612 Medical Arts Bldg

CHRONIC ENLARGEMENT OF THE PAROTID GLAND, HYPERTROPHY AND FATTY INFILTRATION

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and
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The occurrence of chronic bilateral non-inflammatory parotid swelling is well recognized in many malnourished peoples and in patients with chronic alcoholism, obesity and portal cirrhosis

Long standing bilateral asymptomatic parotid swelling has been described in the following undernourished groups Egyptian peasants, certain hill people of Madagascar, Bantus in Africa, some Negro groups in Brazil and in parts of Malaya and rural India Although the condition has been seen associated with pellagra, the general opinion is that a diet which is generally inadequate, rather than a specific deficiency is involved Bilateral parotid swelling is also seen in patients recovering from severe malnutrition, such as infants recovering from kwashiorkor disease, and in emaciated prisoners repatriated from Russian prisoner of war camps Histopathological observations on the parotid are relatively few, but generally show a hypertrophy of the secreting cells with increased number of zymogen granules and a striking absence of an inflammatory reaction Sialograms when done have been reported as normal

The literature on this subject has been extensively reviewed by Sandstead, et al ,[1] in 1955 They report nutritional and clinical studies on three groups an Asian population, 1094 mental patients in Saint Elizabeth's Hospital, D C , and 165 patients in a hospital for American Indians in the Southwest They found parotid enlargement in 11 6 per cent of the Asians, 3 5 per cent of the mental patients, and in 12 per cent of the

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Indians The swelling was bilateral and symmetrical and was occasionally accompanied by an increase in size of the submaxillary glands Parotid function, as estimated by the thiocyanote content of the saliva was normal No evidence of virus infection was found on growing tissue cultures from five biopsy specimens Biopsies were obtained from eight of the enlarged parotids No inflammatory or obstructive changes were seen to explain the enlargement The St Elizabeth's hospital group showed abundant intralobular fat but normal cells, acini and ducts It was thought possible that the fat might be responsible for the enlargement, but it was not present in amounts greater than in normal parotid glands Microscopic examination of the Asian cases showed enlarged parotid lobules with minimal intralobular fat The enlargement seemed to be due to enlargement of the individual cells, which are seen to be packed with zymogen granules They conclude, "The enlargement in the acute phase appeared to be due to swelling of the individual cells and in the chronic phase to a replacement of acinar tissue with fat" After extensive nutritional surveys on these patients they conclude that bilateral chronic asymptomatic swelling of the parotid gland in these cases is a manifestation of recent or remote malnutrition

Dechame et al [2] published a study on a series of French patients with bilateral parotid enlargement which they termed "essential" They classify their cases into four groups on the basis of sialograms and the interpretation of needle biopsies Their first two groups appear to show hypertrophy, while the last two seem to be definitely inflammatory Du Plessis,[3] of Capetown, South Africa, states that parotid enlargement in chronically malnourished people or those recovering from severe nutritional deficiencies is due to an increase in the size of the acini The individual cells are distended with secretory granules and are enlarged up to 50 per cent of normal The glands will revert to normal if adequate nourishment is provided Salamon[4] describes parotid swelling in nine cases of pellagra Five biopsies were done The specimens showed no pathological changes All showed numerous secretory granules in the acinar cells, suggesting parotid hyperfunction

Takaoka, et al.,[5] from experimental work suggest that parotid enlargement may be associated with disturbance in the serum proteins. John[6] reports bilateral parotid enlargement in some cases of diabetes mellitus; however, no pathological findings are described.

Enlarged parotid glands have also been reported in patients with alcoholic cirrhosis and in obese alcoholics without definite evidence of cirrhosis.

Sposito and Chili[7] obtained parotid tissue from six cases of portal cirrhosis. Using a 2 mm. needle, he removed a core of gland through a small skin incision. All cases showed glandular hyperplasia with moderate increase in fatty tissue.

Bonnin, et al.,[8] and Bonnin,[9] from Bordeaux, France, report bilateral parotid swelling in 80 per cent of patients with cirrhosis. Pathological findings in a few cases showed hypertrophy of the acinar cells with complete absence of inflammatory changes. They report an "aquiparus" appearance of the secreting cells, which seems to mean a pale vacuolated cytoplasm with few or no zymogen granules resembling a mucous rather than a serous gland. This appearance may be due to fatigue of the cell after prolonged and excessive stimulation. These authors state that this is the characteristic appearance in the parotids of cirrhosis. Fat was found in normal proportion.

Rothbell and Duggan,[10] of Syracuse, New York, describe six obese patients with liver disease in whom parotid enlargement was a striking finding. Parotid biopsy was done on four cases and revealed various degrees of fatty infiltration. They conclude that the parotid enlargement seems to have much the same significance as a fatty liver, pointing to disturbed nutrition but not defining the disturbance. Wolfe, et al.,[11] of Boston, present clinical and laboratory findings on 16 patients with hepatic cirrhosis associated with chronic alcoholism who had bilateral symmetrical parotid swelling. In some cases, improvement in liver function was accompanied by reduction in the size of the parotid glands. No pathological findings in the parotid were described, but from a study of the literature, they conclude there was no essential histologic difference between the parotid glands of malnourished persons and those of alcoholic patients They conclude that the pathogenesis of the parotid enlargement in liver disease is unexplained, but is probably related to similar changes reported in malnourished persons

Duggan and Rothbell[12] studied 50 persons with non-inflammatory parotid enlargement On the basis of dietary history the patients fit broadly into three categories *1* Abnormal with alcoholism—41 cases, *2* abnormal without alcoholism (3 cases), and unremarkable (6 cases) The parotids were both enlarged but not always asymmetrically Enlargement was diffuse and asymptomatic Obesity and sthenic habitus was common Thirty-five patients had diastolic hypertension, and hepatomegaly was found in 37 No pathological data is presented here After a review of the subject they state that non-inflammatory parotid enlargement is without morphological definition, of unknown cause and of unknown pathogenesis, however, it always seems to be associated with disturbed nutrition, possibly a protein deficiency Enlarged parotids are strongly suggestive of associated liver disease, and provide an indication for the study of glucose tolerance

Fatty infiltration of the parotid has been described occurring in the absence of dietary disturbances In these instances, the change can be unilateral or bilateral, and diffuse or localized

Simonetta[13] describes six cases of a condition which he names Lipomatous Pseudohypertrophy of the Parotid Gland four were unilateral and two were bilateral Two cases were biopsied and revealed diffuse fatty degeneration of the entire gland The proportion of fat cells to acini varied in different portions of the gland, but there was always more than 50 per cent fat The secretory elements were normal No cause for the disturbance was found

Gilman, Schwartz and Gilman[14] report clinical and pathological findings in a thin female American Indian with a discrete mass in the left parotid which was clinically indistinguishable from a benign neoplasm On surgical removal of the mass the histological picture was "parotid gland with

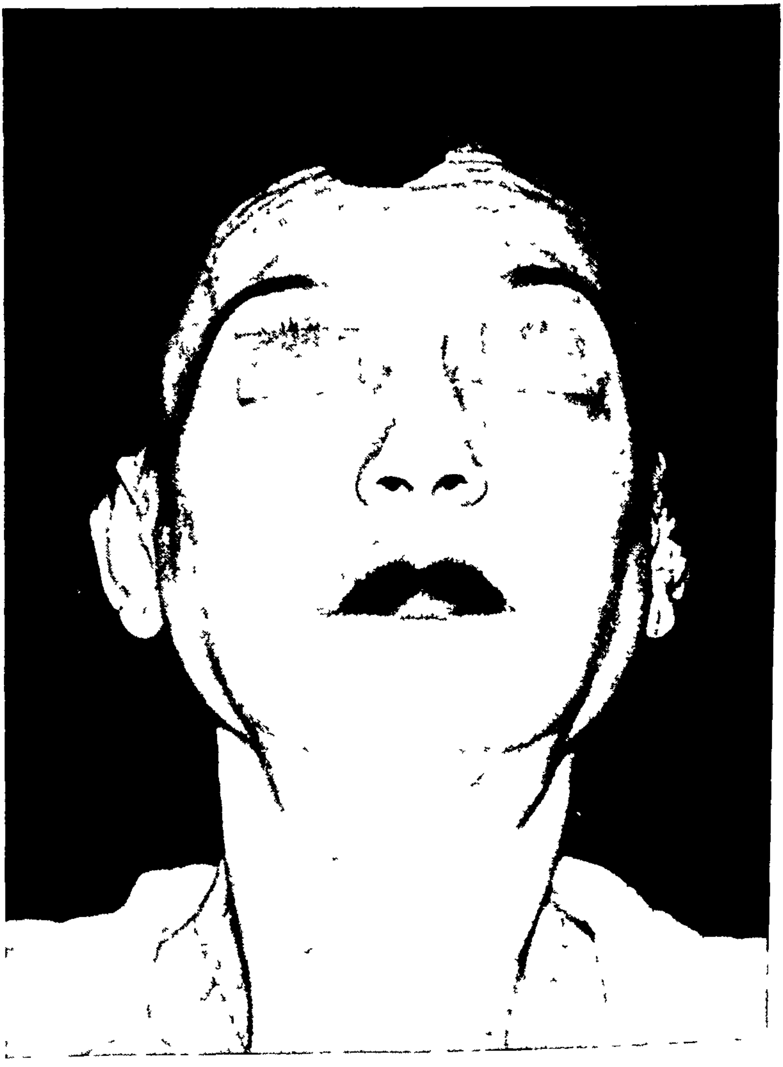

Fig 1 Case 1 A 39-year-old woman with chronic salivary gland swelling for 18 months

a marked fatty infiltration separating the individual acini into groups of various sizes"

For several years the authors have biopsied all diffusely enlarged parotid glands on which the diagnosis was in doubt Biopsy of the parotid gland is an easily accomplished and harmless procedure Under local anesthesia, a small skin incision is made over the parotid below the ear canal and a portion of the superficial lobe of the parotid is removed There is no danger to the facial nerve, and a fistula will not develop If the patient is concerned about the small scar, it can be made more inconspicuous by separating the ear lobule from the face

Following are brief case reports of seven patients who presented with parotid enlargements which were neither inflammatory nor neoplastic.

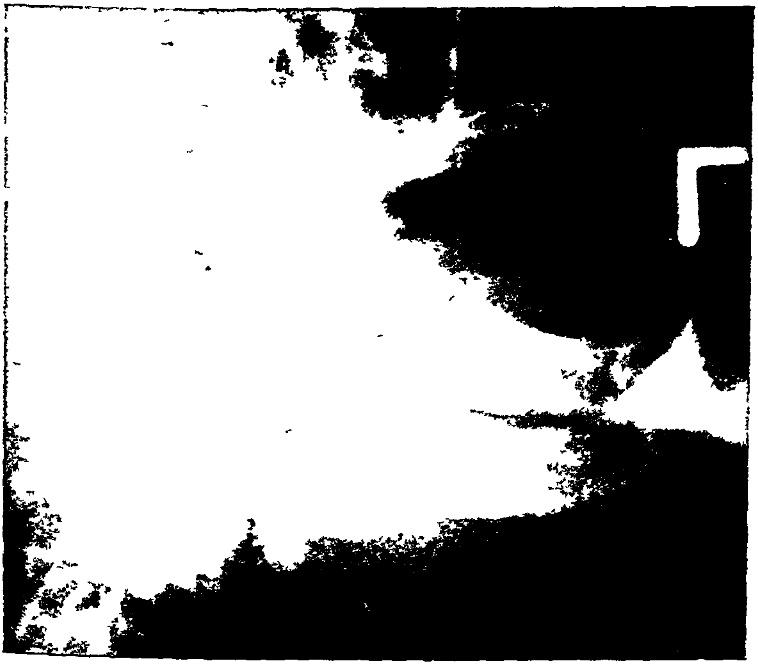

Fig 2-a Case 1 Normal parotid sialogram

Case 1 [illegible] A [illegible]-year-old white female (see Fig 1) Asymptomatic enlargement of both parotid glands, and the left submaxillary gland had been noted for over [illegible] months The submaxillary gland had been biopsied elsewhere, and the patient was assured that the condition was benign When seen in consultation she was a patient on a medical service being studied for generalized malnutrition and pulmonary tuberculosis She weighed only [illegible] pounds [illegible] ounces There was no evidence of alcoholism In addition she showed evidence of a severe [illegible] neuritis Left parotid (see Fig 2-a) and left submaxillary sialograms were within normal limits A biopsy of the left parotid was done (see Fig 2 b) The acinar cells were swollen and stuffed with zymogen granules The acini were almost double the normal size The ducts were normal Practically no fat cells were present A review of the submaxillary biopsy revealed a similar picture At present the patient is under treatment for pulmonary tuberculosis and an effort is being made to improve her nutritional status in the hope that the salivary gland swelling will recede

Case 2 J B, 701568 A 41 year old white female Bilateral diffuse parotid enlargement had been present for at least two years Biopsy revealed ideopathic hypertrophy with a small amount of fat Although she had many complaints, a thorough medical workup revealed no evidence of systemic disease There was no obvious nutritional disturbance or excess intake of alcohol

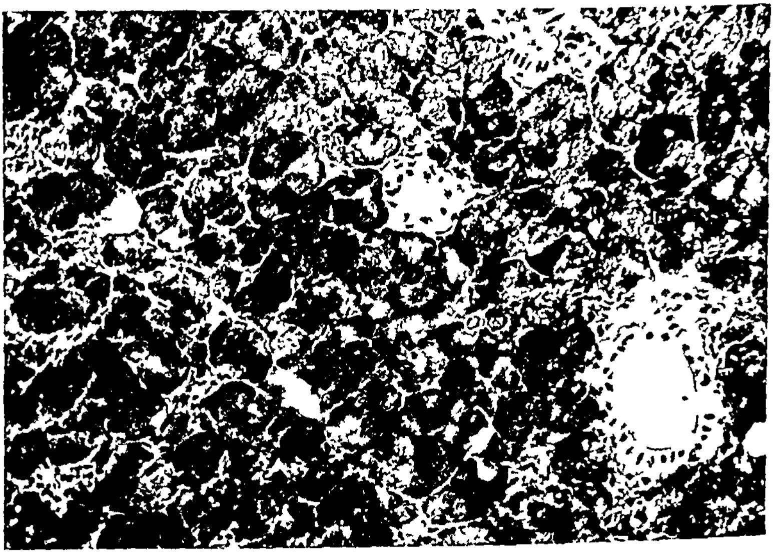

Fig 2-b Case 1 Left parotid biopsy There is no inflammatory reaction but a striking increase in the number of zymogen granules The acini are almost double the normal size

Case 3 S G, 663246 A 46 year old white female (see Fig 3 a) Bilateral painless parotid enlargement had been present for many years She was a very obese sthenic person who consumed several ounces of wine daily Three X ray treatments had been given to each parotid area without improvement She did not complain of dry mouth Liver function tests were within normal limits but a clinical diagnosis of fatty liver was made on the basis of obesity, alcoholism and parotid enlargement Sialograms were normal on both sides A biopsy was taken from the right parotid (see Fig 3 b) There was marked fatty infiltration separating a few small clumps of normal appearing acini The ducts were normal

Case 4 D M C, 664138 This 50 year old white man was undergoing resection and plastic repair for an extensive basal cell carcinoma of the

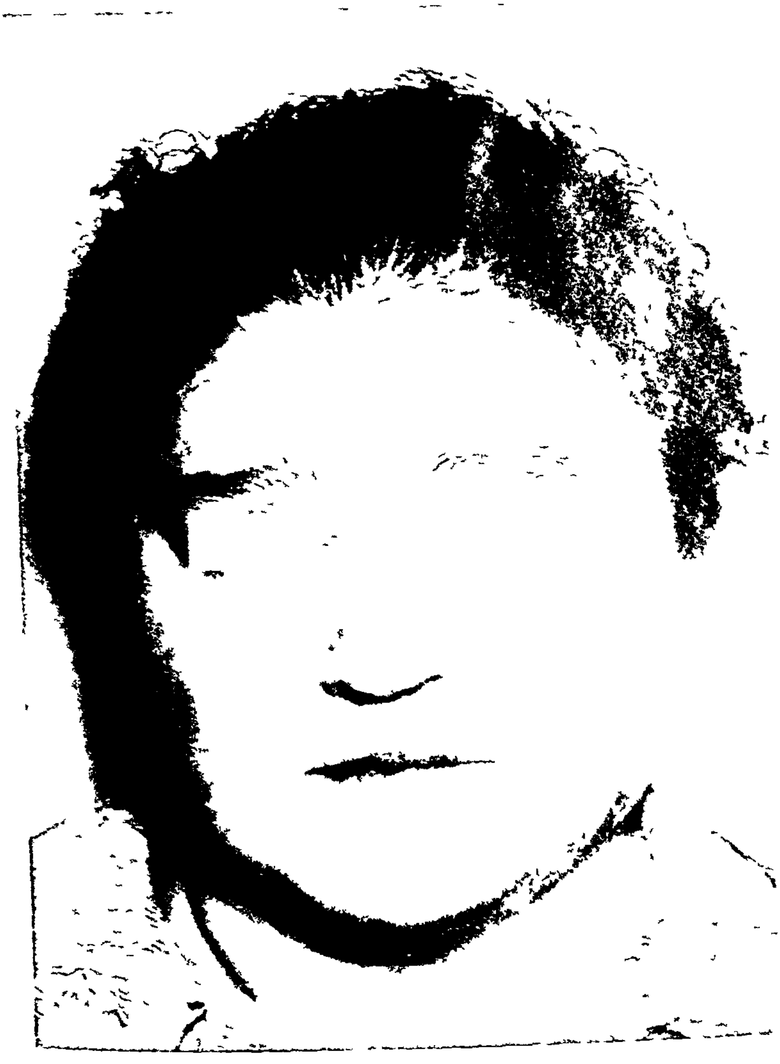

Fig 3-a Case 3 Bilateral parotid enlargement in an obese woman

left side of his face He was moderately obese and had consumed two bottles of beer daily and a few highballs on week ends but had abstained since the development of homologous serum hepatitis two years prior to biopsy Bilateral parotid hypertrophy was noted as an incidental finding A biopsy of the right parotid gland (see Fig 4) was done while a free full thickness skin graft was being taken from behind the ear The section contained about 50 per cent acini and 50 per cent fat The acinar cells are packed tightly with zymogen granules as shown stained with periodic acid Schiff were within normal limits A biopsy of the left parotid was done (see Fig 2 b) The acinar cells were swollen and stuffed with zymogen granules The acini were almost double the normal size The ducts were normal Practically no fat cells were present A review of the submaxillary biopsy revealed a similar picture At present the patient is under treatment for pulmonary tuberculosis and an effort is being made to improve her nutritional status in the hope that the salivary gland swelling will recede

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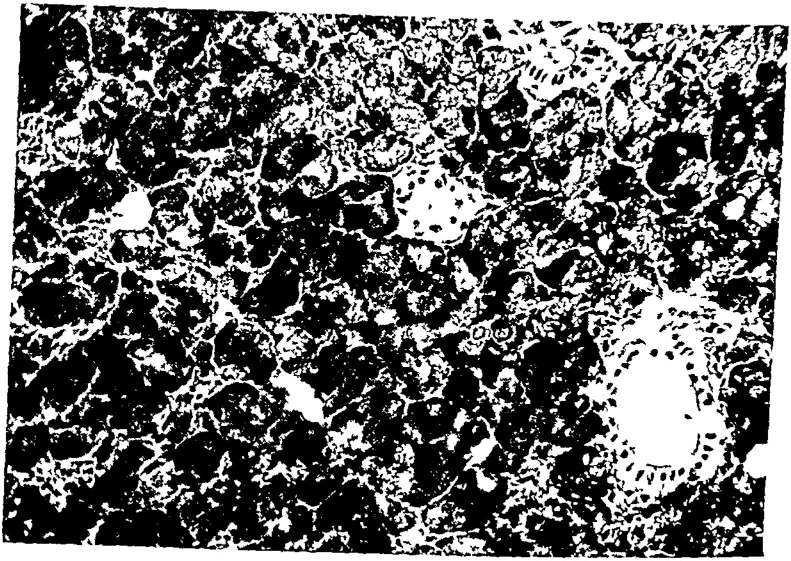

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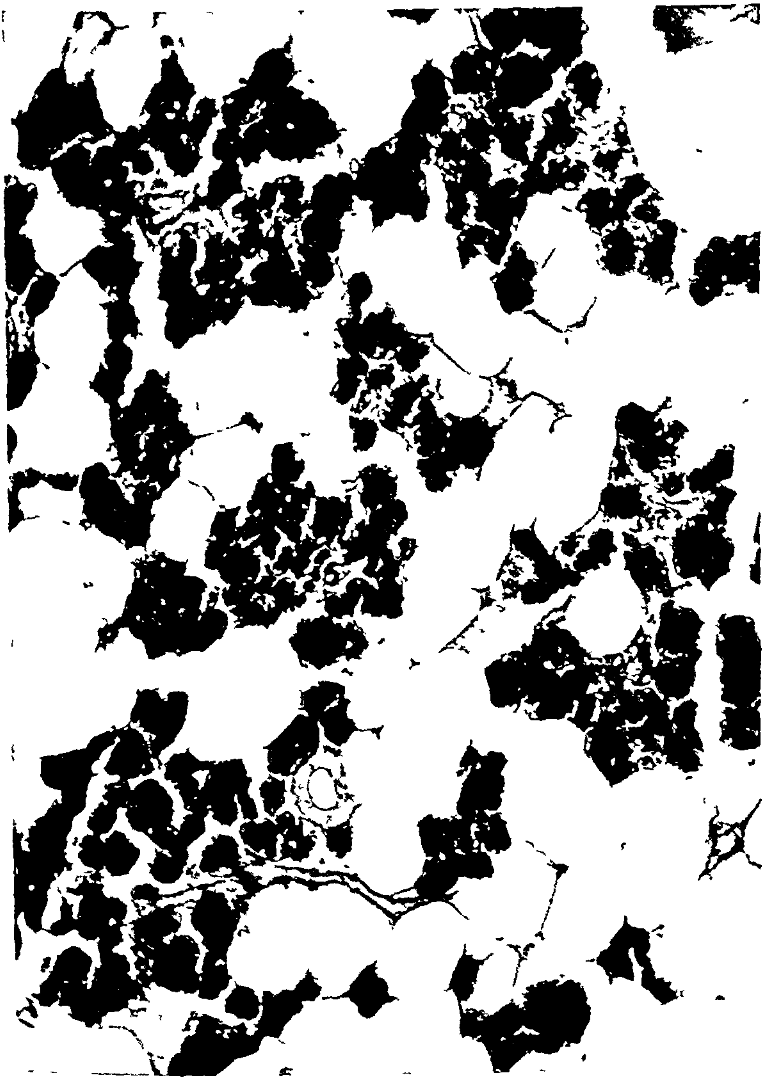

Fig 4 Case 4 Parotid biopsy stained with periotic acid Schiff showing cells packed with zymogen granules

was normal (see Fig 6 a) Biopsy (see Fig 6 b) showed mainly hypertrophy of the acinar cells with about the normal percentage of fat cells

Case 7 M F, a 59 year old white woman, was seen with a diffuse enlargement of the right parotid gland which was clinically double the normal size for about four months A biopsy was performed which showed hypertrophy of the secreting cells, increased zymogen granules and an approximately normal quantity of fat

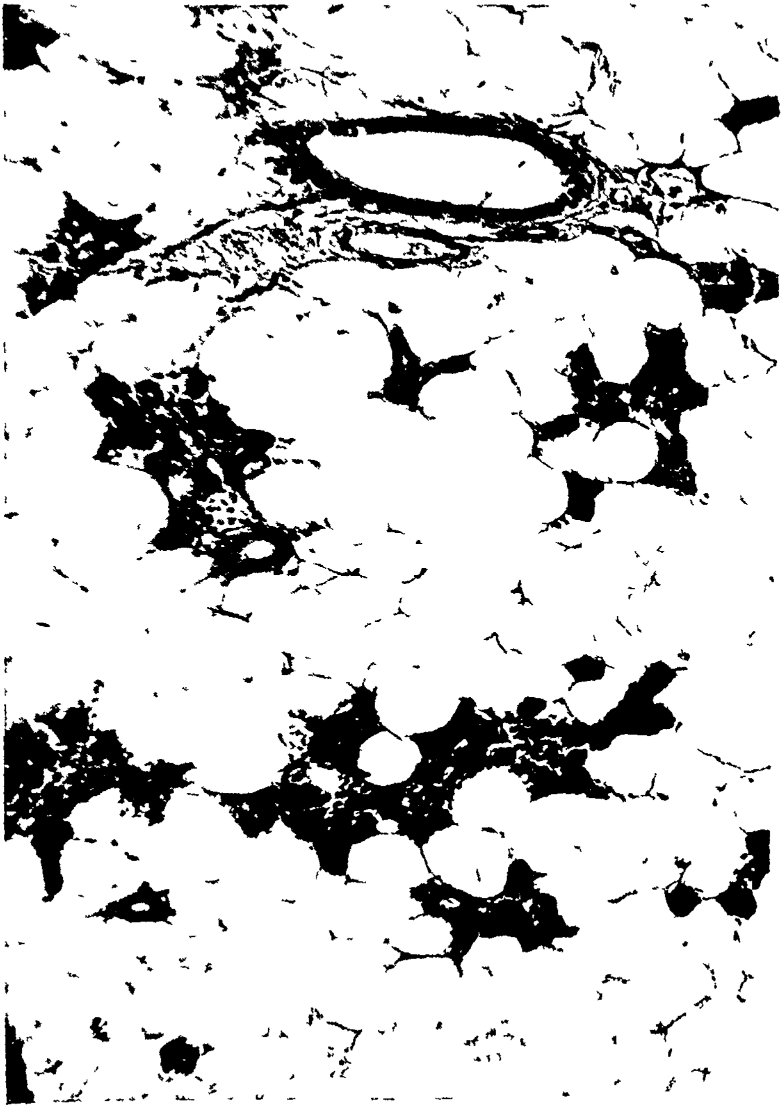

Fig 3-b Case 3 Marked replacement of parotid acini by fat cells

Case 5 M D, 470417 This somewhat obese 58 year old white woman presented with a "walnut sized" mass in the right parotid area for two months Biopsy of the mass (see Fig 5) shows marked fatty infiltration The remaining secreting cells appear to be packed with zymogen granules

Case 6 R O, 475301 This patient was a 37 year old white male who had a diffuse asymptomatic swelling of the right parotid gland for two months He was not obese and drank alcohol very rarely A sialogram

DISCUSSION

Some of the literature has been reviewed on chronic enlargement of the parotid glands which are neither neoplastic nor inflammatory Seven such cases have been described from our material They fall roughly into three groups

1 Ideopathic hypertrophy (two cases), both bilateral

2 Fatty infiltration (two cases), one bilateral and one unilateral

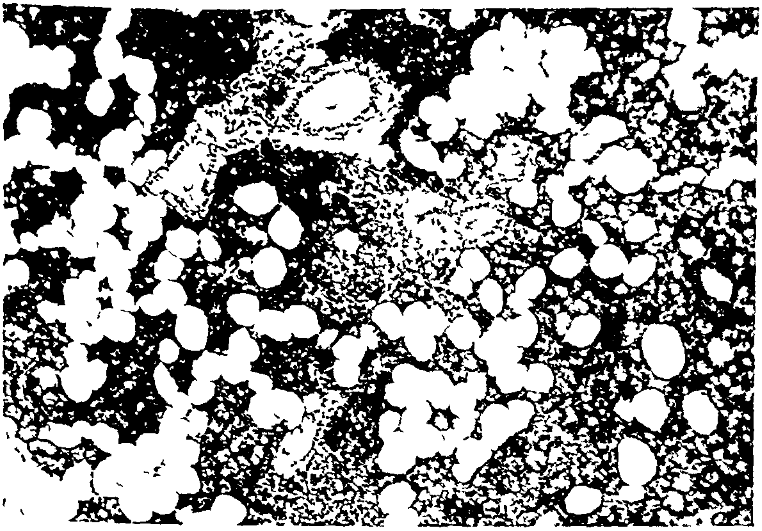

Fig 6-b Case 6 Parotid biopsy Hypertrophy of acini in a unilateral enlargement

3 A combination of one and two-three cases—one bilateral and two unilateral

Case 1 would probably fit into the hypertrophy described in the literature associated with a generalized dietary deficiency, however, Case 2 had no obvious nutritional abnormality Both these patients were psychoneurotic

Cases 3 and 4 correspond to the bilateral hypertrophy seen in obese alcoholics with or without definite evidence of cirrhosis

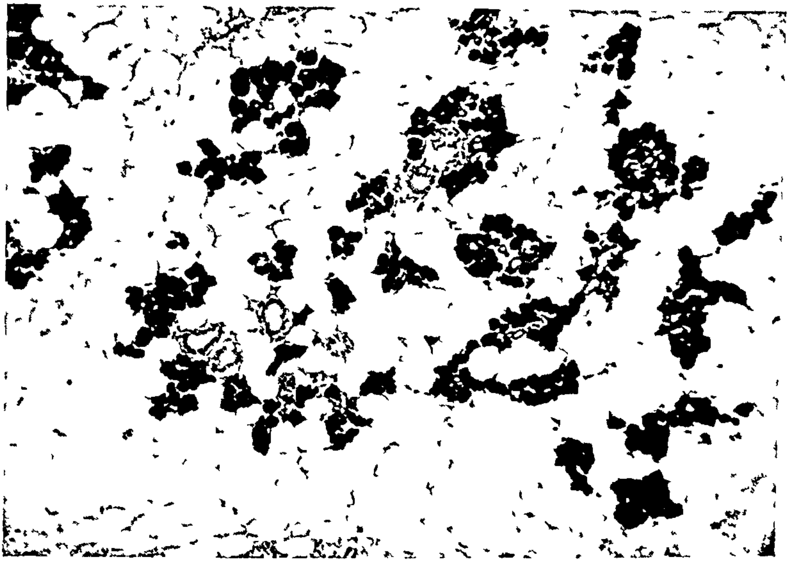

Fig 5 Case 5 Considerable infiltration and increase in zymogen granules in a unilateral 'walnut size' parotid mass

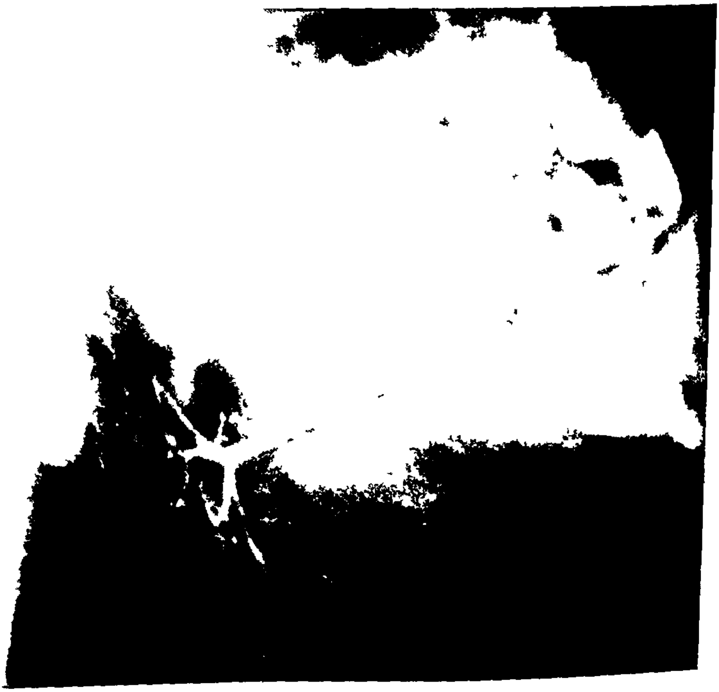

Fig 6-a Case 6 Normal parotid sialogram

indicate that local factors may also be implicated Two of our patients were psychoneurotic, but the remainder appeared reasonably stable The striking occurrence of an increased number of zymogen granules in the cells and the relative absence of resting acini cannot be explained although it would appear the gland was responding to excessive prolonged stimulation

Parotid swellings, due to idiopathic hypertrophy and fatty infiltration, are important only that they should be recognized as absolutely benign entities and not confused with inflammatory or neoplastic parotid disease The bilateral enlargements in malnutrition and obese alcoholics should present no diagnostic problem No local treatment to the parotid is indicated The unilateral diffuse cases and those presenting as localized masses present clinical problems as these lesions often cannot be differentiated from certain inflammatory or neoplastic lesions A sialogram should be done which will be normal in hypertrophy-fatty infiltration Localized lesions should be removed, and diffuse lesions should be biopsied If the patient wished treatment for a cosmetic reason, a partial parotid resection could be performed

SUMMARY

1 The literature has been reviewed on parotid enlargements in nutritional disturbances

2 Seven cases of parotid swelling are presented, in which the pathological changes show a striking absence of inflammatory reaction or neoplastic change Changes seen are quantitative rather than qualitative Increase in size of the individual cells and a striking increase in number of zymogen granules are seen The amount of fat varies from practically none to over 90 per cent in different cases The ducts are normal and sialograms done in four cases showed no abnormality

3 Parotid biopsy is an innocuous procedure and should be done frequently for diagnosis for accumulation of more pathological information about these conditions

4 Etiology and pathogenesis are obscure The hypertrophy

Case 4 is similar to that reported by Gilman, Schwartz and Gilman

Cases 6 and 7 reveal similar pathological findings A mixture of hypertrophy and fatty infiltration was found with acini and fat cells in roughly equal proportions The acini were measured and found to be definitely larger than normal The involvement was unilateral

CAUSE OF THE ENLARGEMENT

Apparently two factors may be responsible for the clinical enlargement of the glands in these patients The first is an increase in the size of the individual acini This is found mainly in glands which show a marked predominance of acini over fat cells In Case 1, measurement of the acini showed that they were almost double the normal size, while in Case 6 and Case 7 the acini were about one-third oversize There is no evidence for an increase in number of acinar cells

Secondly, there may be an increase in the number of fat cells In cases 3 and 5, which showed many more fat cells than acini, the acini were only slightly enlarged or within normal limits The fat cells were measured and found to be of similar size to those found in normal parotid glands The reason for the accumulation of fat is obscure There is, of course, a widely variable number of fat cells in the normal parotid gland, and fat cells replace the acini which atrophy in Sjogren's disease and which are destroyed by X-ray therapy In several of our cases an increase in number of fat cells must have contributed to the enlargement Obviously in intermediate forms the clinical swelling is due to a combination of acinar hypertrophy and fatty infiltration

Our material would seem to support Sandstead's and co-workers' thesis that the hypertrophy and fatty infiltration are different stages of the same process, however, etiology and pathogenesis remain obscure Dietary deficiency undoubtedly plays a role in some cases, but most of our patients had no obvious nutritional defect The occurrence of unilateral involvement in three of our cases would seem to

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ANNOUNCEMENT

The Annual Spring Meeting of the Alumni Association of the New York Eye and Ear Infirmary will take place April 4-7, 1960

The meeting will be oriented towards pediatric otolaryngology Symposia will be offered on Nystagmus as a Pediatric Problem, Diagnosis and Rehabilitation of Hearing Problems in Children, and Ankylosis of the Stapes There will also be a closed circuit television demonstration of surgical procedures In addition, courses will be offered in Allergy and Immunology in Children, X-ray Diagnosis in Ear and Sinus Problems in Children, Pediatric Laryngeal Problems, and Secretory Otitis Media in Children

Additional information may be obtained by writing to Dr John R Finlay, Secretary, Alumni Association, 218 Second avenue, New York 3, N Y and fatty infiltration are probably manifestations of the same process Enlargement is either due to an enlargement of the acini or to an increased number of fat cells or a combination of both Increased number of zymogen granules and lack of resting acini are regularly seen The condition is usually called ideopathic hypertrophy of the parotid if acinar swelling predominates, or fatty infiltration if fat cells predominate

5 The submaxillary glands may show the same reaction either alone or accompanying the parotid enlargement

6 Nutritional factors are involved in some cases, but are absent in others

7 The condition is quite innocuous, and its only importance is that it might be confused with more serious parotid lesions

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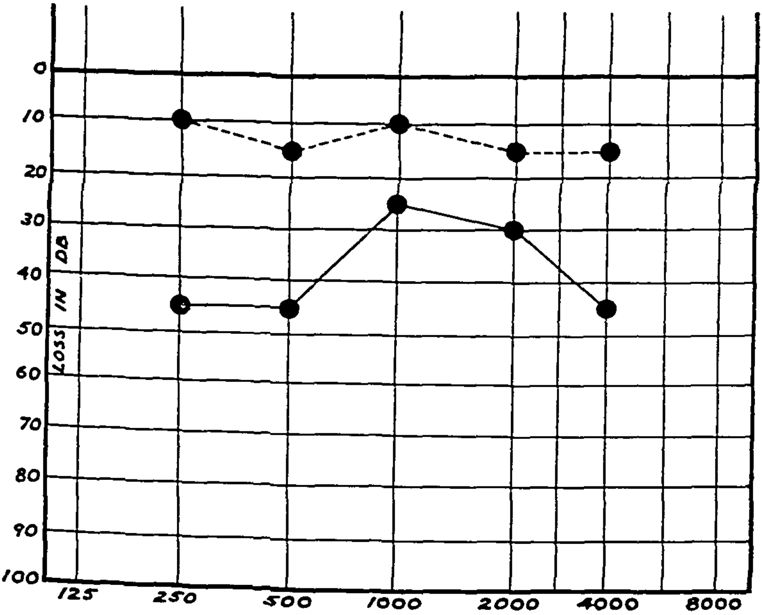

Fig 1

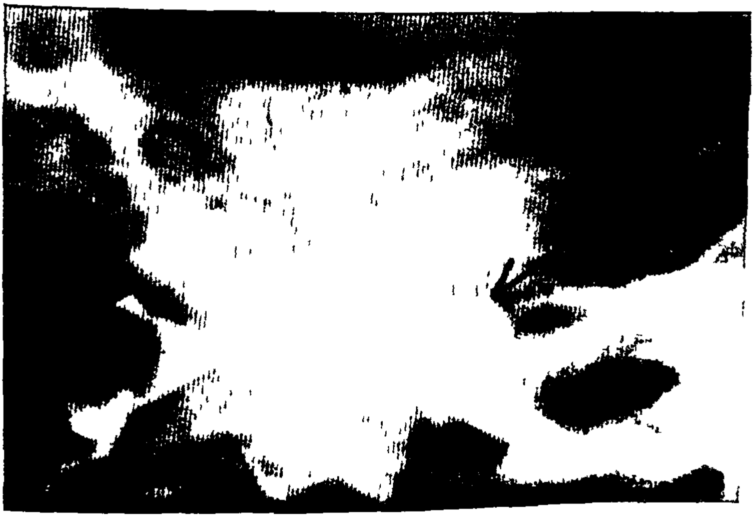

Fig 2 Tympanogram revealing the osteoma obstructing the tympanic portion of the Eustachian tube

OSTEOMA OF THE EUSTACHIAN TUBE *†

VICTOR H HILDYARD, M D ,
and
W E COMPERE, JR , M D ,

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Surgery for the chronically infected ear is now performed to improve the hearing as well as to eradicate disease Before one performs such surgery it is necessary to evaluate thoroughly the function of the middle ear mechanism and the Eustachian tube To study the function of the Eustachian tube a tympanograph is made as first suggested by House and developed by Compere This procedure consists of placing radiopaque contrast media in the middle ear and determining the time required for it to be emptied through the Eustachian tube

It was while employing tympanography that an osteoma was discovered at the tympanic orifice of the Eustachian tube A review of the available literature does not mention osteoma as a possible cause for obstruction of the Eustachian tube and, therefore, I am making this case report

Bones developing in the membrane, which include most of the bones of the skull, ossify directly in a primitive connective tissue The primitive connective tissue cells become changed into osteoblasts, which lay down bone Such bones are not liable to the development of primary tumors In general terms, it may be said that osteoblasts may give rise to osteomas, which are not true tumors, but rather a formation of new bone arising from the surface and known as exostosis They are usually caused by irritation of the surface of the bone In this case the chronic discharge could be the irritant

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†Sponsored by the Los Angeles Foundation of Otology

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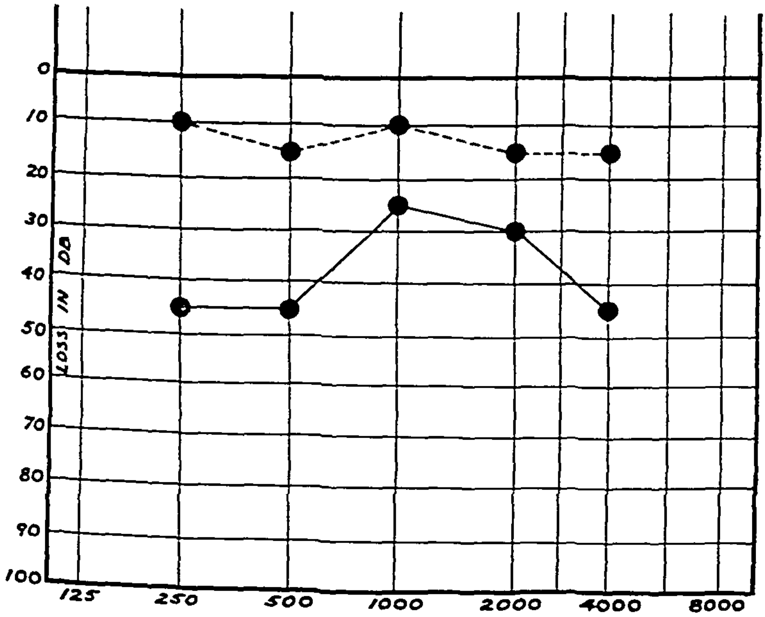

Fig 1

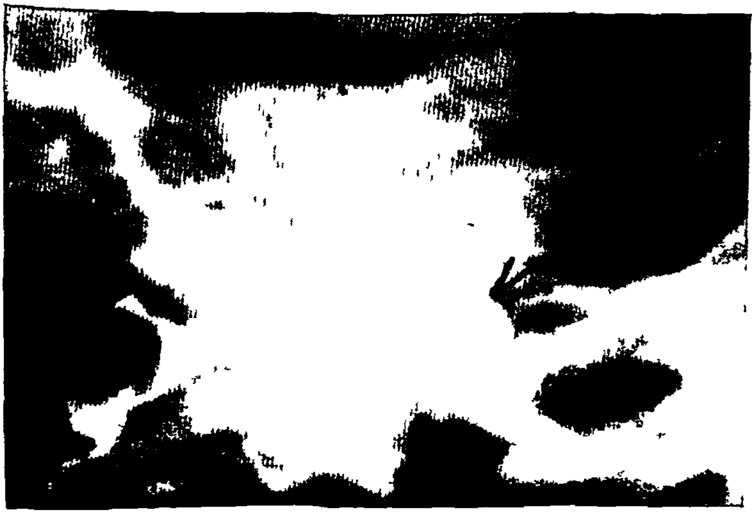

Fig 2 Tympanogram revealing the osteoma obstructing the tympanic portion of the Eustachian tube

CASE REPORT

Miss M R, age 22, was first examined on Nov 29, 1957, because of a hearing loss since the age of seven years The patient stated that she developed drainage from both ears at the age of seven years The infection in the left ear subsided with therapy, but the right ear continued to drain intermittently throughout the years

Examination of the right ear revealed a central perforation approximately 4 mm in diameter There was no drainage from the ear Examination of the left ear revealed a healed central perforation The remainder of the examination of the ears, nose and throat was essentially negative

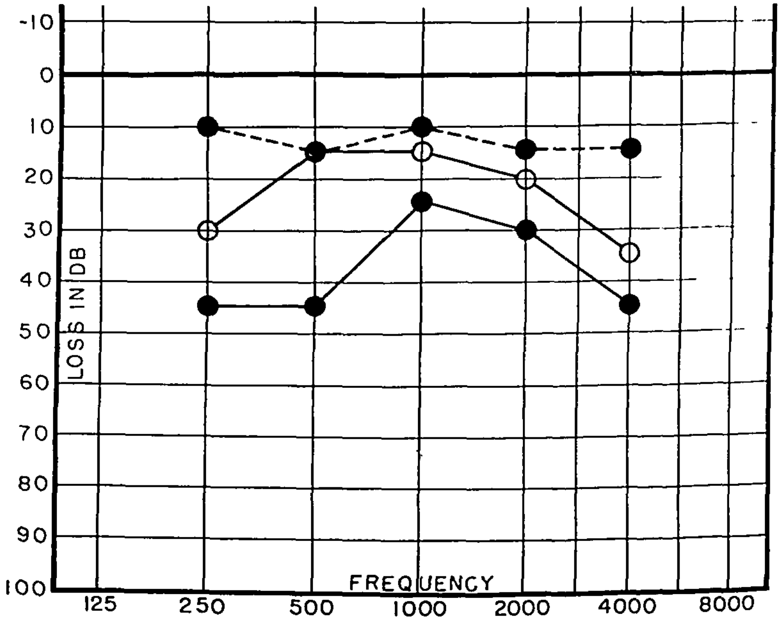

Fig 3 Postoperative Audiogram

Auto inflation of the right Eustachian tube was not effective The acoustic probe revealed that sound was perceived better through the ossicular chain than through the promontory

Audiometric examination revealed a conductive type hearing impairment of 33 db in the right and 23 db in the left ear, as indicated in the audiogram

A tympanogram by Compere revealed obstruction to the contrast media at the tympanic orifice of the Eustachian tube with a clear outlining of a small osteoma

A myringoplasty was performed on her right ear on Jan 4, 1958 At the time of this procedure it was noted the tympanic portion of the Eustachian tube was completely obstructed by a smooth, hard, white, rounded growth of bone from the inferior bony wall of the Eustcahian tube, which measured approximately 4 mm in diameter The growth was readily removed with a small curette and a skin graft was placed over the de-epithelized ear drum

The patient made an uneventful recovery, and the hearing improved to a 17 db average level, as per the postoperative audiogram

The postoperative X-ray of the right temporal bone on June 20, 1958, revealed a postoperative defect where the osteoma had been removed

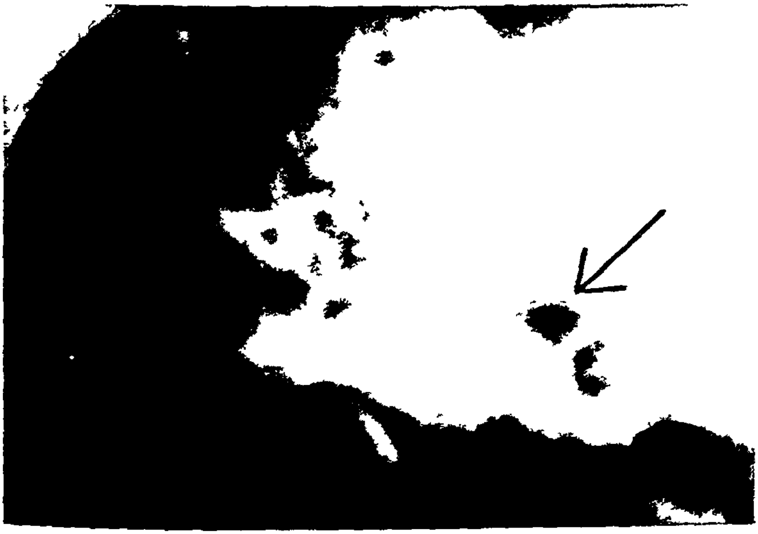

Fig [illegible] Postoperative X-ray showing defect after removing osteoma

SUMMARY.

An osteoma obstructing the tympanic portion of the Eustachian tube was diagnosed preoperatively by means of a tympanogram. This entity may now be added to the other causes of possible Eustachian tube obstruction

SKELETAL MUSCLE RHABDOMYOMA OF THE LARYNX REPORT OF A CASE [*]

HOWARD W SMITH, M D ,

New Haven, Conn

A benign tumor arising in skeletal muscle and composed chiefly of muscle fibers containing both longitudinal and cross striations is a striated muscle rhabdomyoma Such a tumor is exceedingly rare, for Willis,[1] 1950, stated that benign rhabdomyomas of skeletal muscle are unknown in spite of the very large mass of voluntary muscle in the body Rhabdomyomas of skeletal muscle are exceedingly rare The classical description was recorded by Ewing,[2] in 1919 He described this tumor as "composed chiefly of a system of parallel bundles or intertwining strands of striped muscle fibers, supported by adult or embryonal connective tissue The cells were usually thin, much elongated and rarely they were branching Both longitudinal and cross striations may be pronounced, or the cross striations may be present in a part of the cell only or be entirely missing in embryonal or spindle shaped cells which still retained their longitudinal fibrillations The cells may closely resemble smooth muscle cells in some areas "

A number of laryngeal tumors have been reported under the term "rhabdomyoma" but described as granular cell myoblastomas [3,4] Imperatori,[3] 1933, reported a case of rhabdomyoma of the larynx He described the tissue mass as coarsely papillary and firm with a cut surface which was homogenous and pale yellow in color Microscopic sections were reported to show striated muscle fibers of varying size and shape, and a small amount of fibrous tissue intermingled with the muscle fibers Parsons,[5] 1955, reported a case of rhabdomyoma of the sternothyroid muscle He could find no

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previous case reports of rhabdomyoma arising from skeletal muscle

A closer look at the photomicrographic illustrations of the case reported by Parsons, in 1955, raises certain objections to the use of the title rhabdomyoma, for the lesion as demonstrated was composed chiefly of granular cells having questionable striations and showing little, if any, resemblance to striated muscle

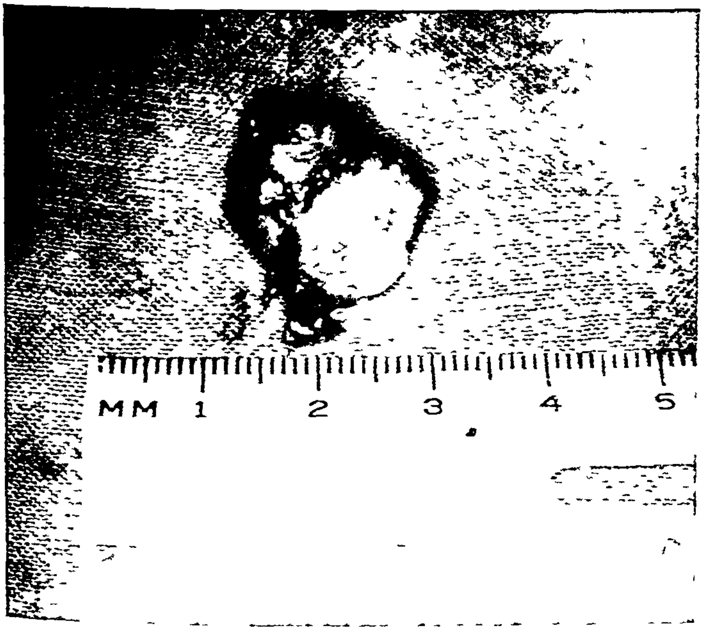

Fig 1 Photograph of striated muscle rhabdomyoma removed from the larynx.

Seventeen cases of granular cell myoblastoma of the larynx have been reported[6-7] It is possible that a number of this group may be true rhabdomyomas, as striated muscle elements have been noted in the microscopic sections in a few of the cases Schirmer and Meyer[6] attributed such findings to erroneous interpretation of the relation between neoplastic elements and pre-existing striated muscle fibers The relation of granular-cell myoblastoma to striated muscle seems to be more tenuous as time goes by The idea that the granular cells are embryonic precursors of striated muscle fibers is now generally rejected[6] That it may be a degenerative lesion of muscle is supported by Willis,[9] 1953 Still others believe it to have a neurofibromatous nature[10]

The only known case report of a benign striated muscle rhabdomyoma meeting Ewing's classical description, other than the case reported by Imperatori, is that of a rhabdomyoma of the nose reported by Reitter in 1921[11] He described the tissue as consisting of irregular bundles of fibers closely resembling those of striated muscle The bundles consisted of a varying number of fibers running in many directions without regular arrangement Each fiber had a distinct sarcolemma and cross striations were visible The fibers were found to be somewhat coarser than those of normal striated muscle The bundles of fibers were separated by

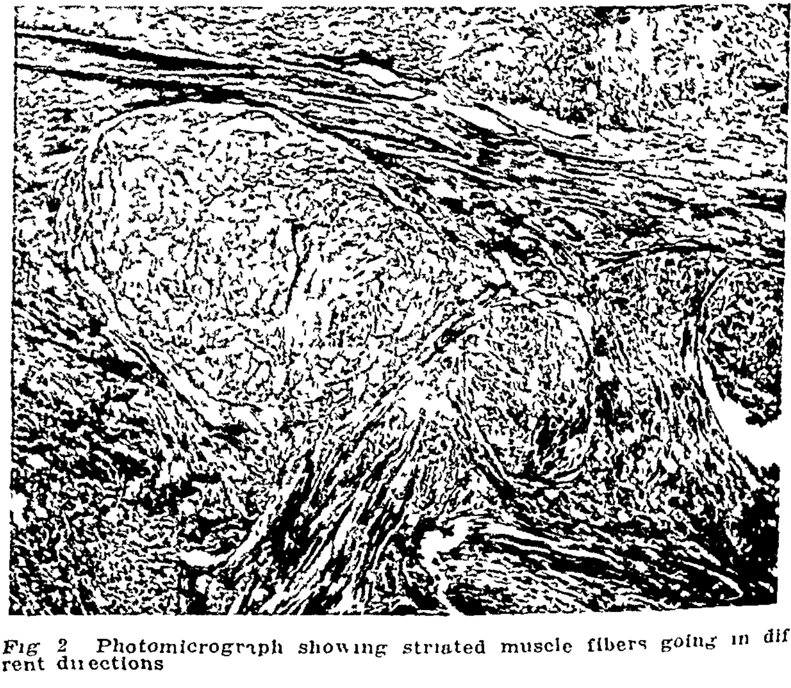

Fig 2 Photomicrograph showing striated muscle fibers going in different directions

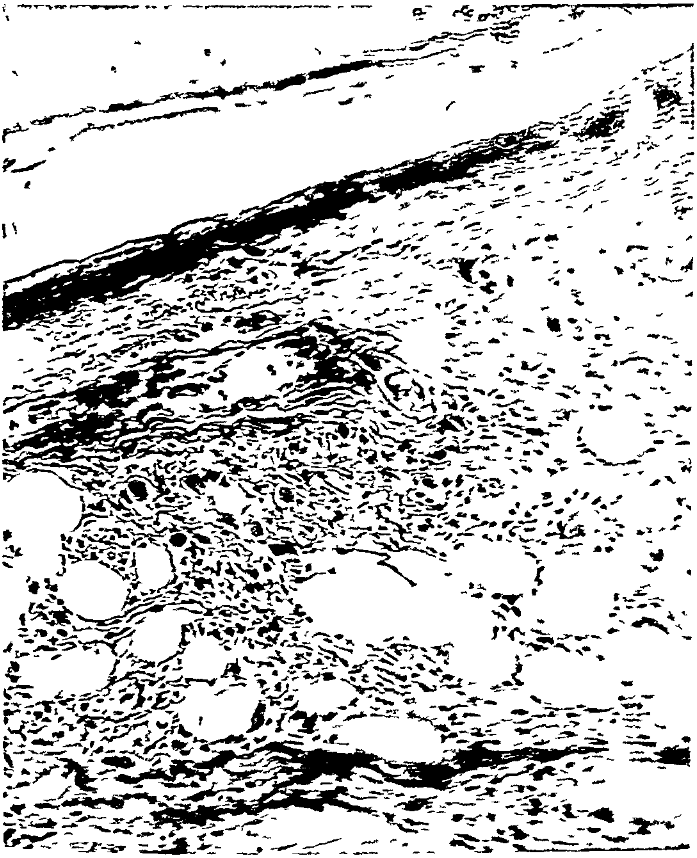

Fig [illegible] Photomicrograph showing fatty infiltration

areas of delicate connective tissue No reference to granular cells was found in the histopathologic report

CASE REPORT

A 39-year-old white female was admitted to the hospital because of longstanding hoarseness a mass in the larynx and a recent episode of choking

At age eight, the patient was examined because of hoarseness An irregularity of the larynx was observed at that time but no treatment was recommended. The hoarseness had remained unchanged since that time

Three weeks prior to admission the patient had an upper respiratory infection and complained of choking and the presence of a mass in her throat. Examination revealed an irregularity of the larynx

Admission physical examination showed a well developed and well

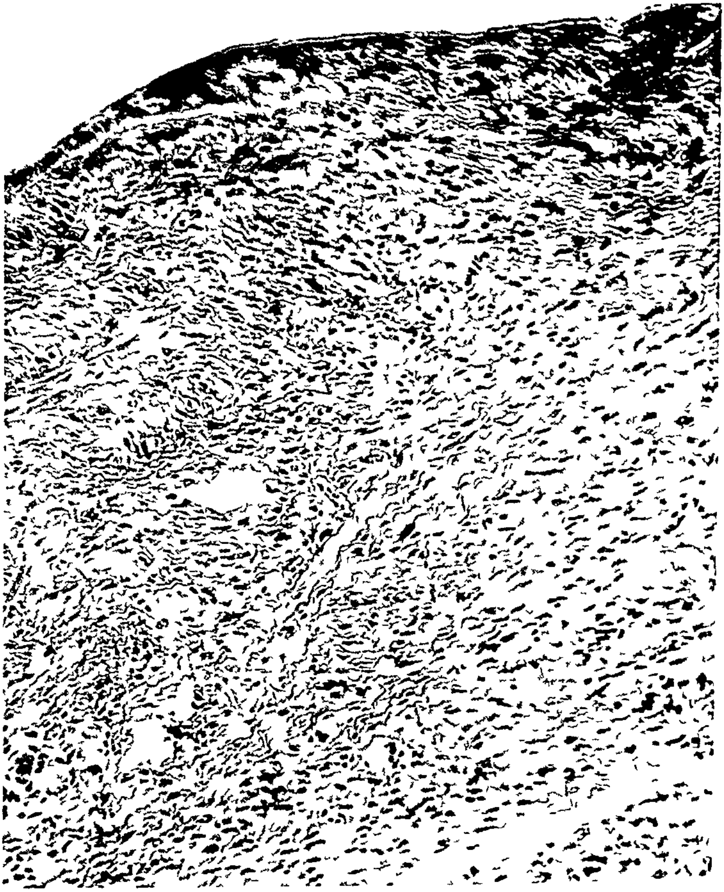

Fig 4 Photomicrograph showing replacement of muscle fibers with dense collagenous tissue and absence of capsule

nourished white female in no distress The voice was very husky, and there was much wasting of the air stream causing her to speak slowly and in short sentences Physical findings were essentially normal, except for those observed by mirror laryngoscopy The right half of the glottis was occluded by a medial displacement of the right lateral wall The right true vocal cord could not be seen There was limited movement of the right false cord The remainder of the larynx appeared normal Food and liquids were swallowed without difficulty No abnormal masses were palpable in the neck There was slight tenderness over the right half of the larynx

Admission blood and urine studies were normal A metastatic X ray series and barium swallow were normal Special X rays of the larynx revealed asymmetry of the tracheal air column on the right This asymmetry appeared as an impingement of the airway at the level of the right glottic and subglottic area

On the second hospital day a tracheotomy was performed under local anesthesia and followed by direct laryngoscopy under general anesthesia

The whole right half of the intrinsic laryngeal structures appeared to be forced over to the midline The right true vocal cord appeared to be displaced medially and downward There was a firm moveable mass between the true and false vocal cords which could be demonstrated by displacing the overlying mucosa and intrinsic muscles Immediately following laryngoscopy a laryngofissure was performed A soft moveable mass was palpated in the right half of the larynx It appeared to lie against the laryngeal cartilage deep to the mucosa and intrinsic muscles The major portion appeared to be between the true and false cords, but there was definite extension beneath the true cord into the subglottic area The right vocal cord was detached anteriorly and retracted medially to expose the tumor mass The tumor was intimately related to the intrinsic musculature and lay between it and the perichondrial lining of the right alar cartilage The tumor was quite soft and polypoid No muscle fibers appeared to run into the mass It seemed to be intimately related to the muscles of the larynx but in no way attached to them The mass was yellow in color and easily distinguished from the muscle fibers When the mass was removed the true cord was re-attached in its normal position and the larynx closed There were no complications following surgery and the tracheotomy tube was removed on the eighth postoperative day Gradual improvement of the voice has been observed since that time

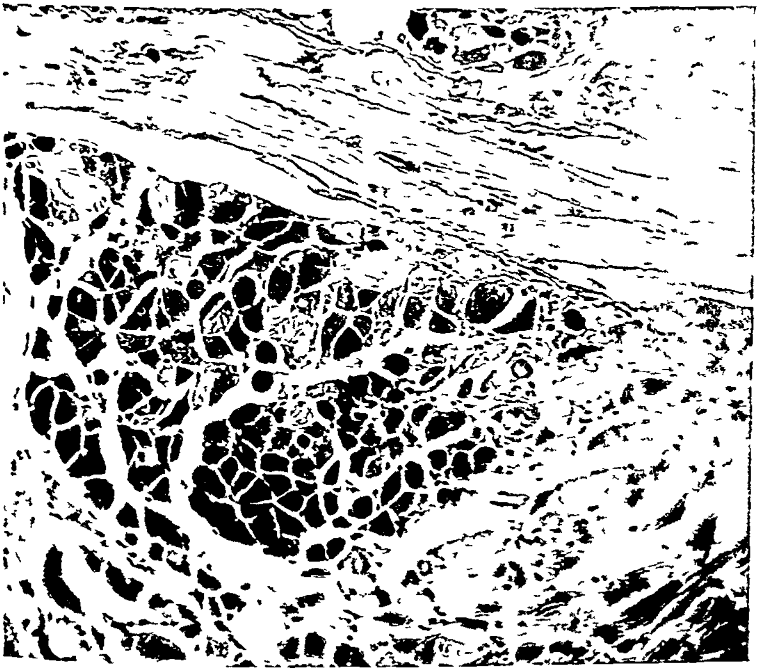

Fig 5 Photomicrograph of striated muscle fibers in cross section Note peripheral position of nuclei

The specimen sent to the pathology laboratory was reddish-yellow soft lobulated mass measuring 3x2x1 cm (see Fig 1) The cut section appeared to have a lobulated architecture with small yellow pock marks Microscopic examination revealed a mass of striated muscle fibers haphazardly arranged in bands and large bundles going in different directions (see Fig 2) There was also a moderately large amount of fibro adipose tissue and several areas showed striated muscle infiltrated with fatty elements (see Fig 3) There was some hyalinazation of muscle fibers and replacement with dense collagenous tissue in a few areas (see Fig 4) Examination of the muscle fibers under high power in cross section (see Fig 5), and in longitudinal section (see Fig 6), revealed peripheral placement of nuclei and unequivocal longitudinal and cross striations The nuclei of the muscle fibers did not seem unusual in size, staining characteristics, or configuration, and there was no indication of malignant transformation

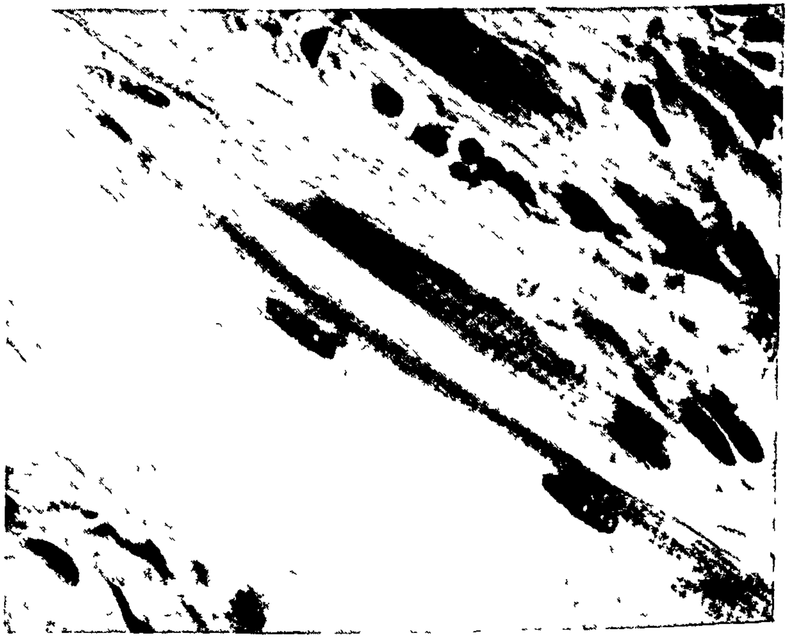

Fig 6 Photomicrograph of striated muscle fibers in longitudinal section Note presence of both longitudinal and cross striations

DISCUSSION

The above case report conforms to the classical description of benign rhabdomyoma of skeletal muscle as described by Ewing in 1919 The only known case reports which bore any true resemblance to Ewing's description was a rhabdomyoma of the larynx reported by Imperatori,[3] 1933, and a rhabdomyoma of the nose reported by Reitter[10] in 1921

The tissue mass in the present case report bears little, if any, histologic resemblance to the lesions described in the cases of myoblastoma tabulated by MacNaughtan, et al.,[6] 1954, and Hinton, et al.,[7] 1958. Their lesions were for the most part superficial projections from the true or false cords or raised plaques intimately associated with the epithelium. Their removal in most instances was accomplished by peroral laryngoscopy and forceps removal. When one understands the procedure it is easy to interpret a report on the histopathology which reads "striated muscle fibers were noted." In addition, MacNaughtan considered the granular cells myoblastoma to consist of sheets or clumps of large round cells, the cytoplasm of which is always granular and often acidophilic. The present case fails to qualify for definition as granular cell myoblastoma.

Now that the origin of the granular cell has been challenged as to its being the precursor of skeletal muscle and even considered as a degenerative process of muscle or of neurogenic origin, one can no longer consider a tumor arising in striped muscle, made up primarily of varying arrangements of striated muscle elements as a granular-cell myoblastoma. The case reported by Parsons, et al.[4] would be somewhat more acceptable as a benign striated muscle rhabdomyoma if the striations had been demonstrated on muscle fibers where proper and unequivocal distinction could be made, instead of showing waves in the granules of large round cells presumably cut on cross section.

The obscure and broad origin of granular cell tumors and their frequent classification as benign rhabdomyomas of skeletal muscle should not be so gross as to include those tumors arising in skeletal muscle showing true muscle fibers, unequivocal longitudinal and cross striations and containing no granular cells.

SUMMARY

A true benign striated muscle rhabdomyoma of the larynx presenting symptoms for over 30 years has been reported. This tumor conforms to the classical description of the striated muscle lesion presented by Ewing in 1919, except for the fibro-adipose elements which may also qualify the tumor as a hamartoma One previous case report of a striated muscle rhabdomyoma occurring in the larynx was found

The continued interchangeable use of the terms "granular cell myoblastoma" and "rhabdomyoma" to describe tumors composed of large vacuolated granular cell masses of dubious origin is deplored

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Applications may be addressed to the Department of Postgraduate Medicine, University Hospital, Ann Abor, Mich

A METHOD OF REMOVING A BEAD FROM A BRONCHUS

An Improvement in Procedure

J J Cantor

Los Angeles, Calif

During 1922, while in the employ of Dr Simon Jesberg, I was called upon to design and construct an instrument for the removal of an oval bead with a hole 1/32-inch in diameter from the right bronchus of a 14-months-old child [1]

The instrument that was devised was essentially a long crochet needle-like stylet of small enough cross section to pass easily through the hole in the bead An eye in one end of the stylet was slotted so that it could be threaded (see Fig 1) A continuous rubber band was hooked into this opening and then drawn down to a very thin cross section The rubber band was cut from a sheet of the thinnest grade of dental rubber by two thin Gillette safety razor blades, which were clamped on opposite sides of a 3/32-inch piece of flat metal (see Fig 2) The ends of the rubber strip were tied together to make a continuous rubber band

In use, the proximal end of the stylet, with its tightly stretched rubber band, was passed into the hole in the bead (see Fig 3) and the distal end of the rubber band, to which a thread had been attached in order that it not be lost down the bronchoscope, was gradually released As the rubber band slowly contracted it increased in cross section, filled the hole in the bead and locked the bead to the stylet The stylet, with its attached bead, was then withdrawn

The success of the procedure depended upon the smoothness of the razor cuts, for it was found that even a small nick in the edge of the band would cause it to break when stretched In this particular case, out of the hundreds of bands cut, only a few satisfactory bands were obtained In the years fol-

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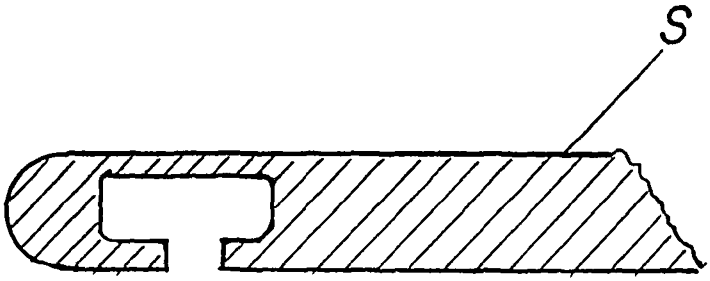

Fig 1 Stylet

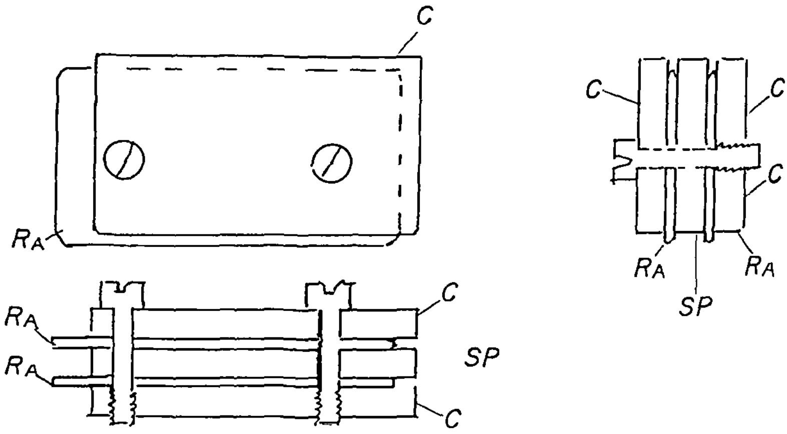

Fig 2 Cutting Instrument (three views)

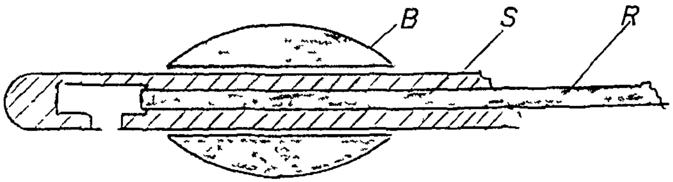

Fig 3 Stylet in bead with rubber band stretched

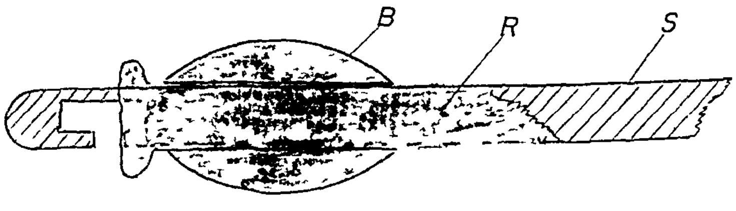

Fig 4 Stylet rubber band and bead locked together

Abbreviations B—bead C—clamp R—rubber band Ra—razor blade S—stylet Sp—spacer lowing the successful removal of this bead, I speculated upon numerous more efficient methods of producing smooth edged rubber bands

Some 22 years later I was called in by Dr Howard P House, who had a similar bead case At this time I employed a different method of cutting the rubber band

First, I glued a piece of dental rubber between two sheets of kraft paper, using water soluble LePage's glue The whole was allowed to dry upon a flat surface over night When the sandwiched sheets of paper and rubber were thoroughly dry, I had no difficulty cutting smooth bands with the razor blade device shown in Fig 2 The bands, with their attached paper, were dropped into a bowl of cold water The water dissolved the glue, and the paper floated away from the rubber strip

Dr Howard P. House, assisted by Dr Harold Owens, used the instrument described above to remove the bead through the tracheotomy wound

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